PROCEDURES FOR THE ASSESSMENT OF SOLID WASTE RESIDENTIAL AND COMMERCIAL

VOLUME III OF THE ONTARIO WASTE COMPOSITION STUDY

JULY 1991

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VOLUME 111
OF THE ONTARIO WASTE COMPOSITION STUDY
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Report prepared by:
GORE & STORRIE LIMITED

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INFORMATION FOR THE READER

The results of the Ontario Waste Composition Study appear in three volumes.

Volume I contains the results of the residential portion of the Ontario Waste Composition Study. The emphasis in Volume I is on the development and testing of a method that municipalities can use to estimate per capita generation rates of residential refuse. The field work for Volume I took place in East York, Fergus, and North Bay, Ontario.

Volume II contains the results of the commercial portion of the Ontario Waste Composition Study. Waste generation data for two light industrial businesses are also provided in Volume II. The emphasis in Volume II is on the development and testing of a method that municipalities can use to estimate per employee waste generation rates and, further, to estimate the quantity of waste generated from all commercial sources. The commercial component of the study took place in the Regional Municipality of Waterloo.

Volume III is a "user friendly" manual that outlines the procedures for conducting residential and commercial waste composition studies in municipalities of Ontario. While every effort has been made to present as complete a description of the method as possible there will be instances where the persons conducting a waste study will find it necessary to make adjustments to this method to suit particular circumstances.

Volume III is divided in two parts. Part A provides a description of the methodology used to conduct the Residential Waste Composition Study. Part B describes the methodology used to conduct the Commercial Waste Composition Study.

PART A

RESIDENTIAL WASTE COMPOSITION STUDY METHODS

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Methodology

The two-fold purpose of the residential portion of the Ontario Waste Composition Study was to:

1. develop a simple, cost effective and statistically reliable method for determining the composition and per capita generation rate of waste from residential sources in Ontario municipalities; and

2. apply the method in several municipalities and obtain current information on the characteristics of residential waste streams.

The pre-study literature survey, summarized in Volume I - Residential Waste Composition Study, indicated that residential waste generation was a function of the socio-economic and demographic characteristics of a population. An assessment of the residential waste generation characteristics of a municipality should take population demographics into consideration.

The socio-economic and demographic parameters incorporated in the Residential Waste Composition Study are: income level and housing type. Statistics Canada provides census data with respect to these parameters for municipalities across the country and this kind of information was obtained for the three municipalities participating in the waste composition study in Ontario: the Town of Fergus (population: 6,757); the Borough of East York (population: 101,085); and the City of North Bay (population 51,313). The field studies were conducted in the three municipalities during the following periods: July 15 to August 31, 1989; October 24 to December 28, 1989; and February 21 to February 28, 1990 respectively.

Statistics Canada provides socio-economic and demographic information on small geographical sectors of municipalities called Enumeration Areas (EAs) that are made up of approximately 300 dwellings and typically have a residential population of 600-800 persons. Some highrise apartment buildings may have a large enough number of units that they are designated as EAs unto themselves.

In the work reported herein, the EA was the basic population unit whose waste composition and per capita generation rates were studied as representative segments of the entire municipal population. First, all of the EAs in the municipality were classified in a three-by-three, two dimensional matrix of:

Average annual income:	high, medium, and low; and
Housing type:	single detached dwellings, predominantly multiple dwellings (apts.), and predominantly mixed (detached/apts.).

This classification matrix resulted in nine possible combinations of income levels and housing types with each combination termed a "cell". One EA was randomly selected from each cell, unless the cell contained few or no EAs, which was often the case for the low income/single detached dwelling cell. The residential waste assessments in the Town of Fergus and the Borough of East York were based on data from EAs that were representative of the EA distribution in the income/housing matrix for the respective municipalities. Based on the results of these two municipalities, it was decided to conduct a reduced sampling program in the City of North Bay.

After the Study EAs in the municipality were randomly selected, a curbside refuse sampling plan was designed, based on a procedure that assigned random starting points for refuse collections at street intersections throughout the EA.

For each EA, both the number and weight of the refuse samples that had to be collected and sorted in order to obtain the statistical accuracy that was desired for the kitchen waste fraction (only) of residential waste was based on the pioneering work of Dr. A. Klee and co-workers. The sample number was a minimum of nine per EA; and the minimum sample weight was 100 kg. To achieve similar levels of statistical accuracy for waste components occurring at lower concentrations in the waste stream (for example, glass and ferrous metals), a greater number of samples, which may be economically impractical, would be required. To determine the number of samples required to accurately assess these waste components refer to Volume I, Section 1.2.

It took a crew of four, approximately 5.5 days to collect and sort the bagged refuse and Blue Box materials in a single EA. Records were kept of the number of dwellings from which bagged refuse and Blue Box materials were collected in order to compute estimates of total residential waste generation on a per capita basis, using Statistics Canada data on the average population per dwelling in the EA. Blue Box materials were sorted, weighed and recorded separately in order to estimate the capture rate of certain recyclable items from the residential waste stream.

Yard wastes were weighed and recorded whenever they were encountered, but this waste stream was not included in the computations of the residential waste composition and the weight was not included in the estimates of per capita generation rates either, for seasonal generation reasons discussed herein.

The moisture content of the combustible fractions of the waste stream was determined by drying. The BTU content of some mixed plastics (laminates), as well as disposable diapers, was determined by bomb calorimetry. Samples of vacuum cleaner bag dust were analyzed for heavy metals. The results of these analyses are presented in Volume I.

Special sampling procedures were devised for those apartment buildings where the waste was compacted in containers. Samples of the required weight were removed from the containers for the waste composition analysis. Then the residual contents were collected and weighed, courtesy of special arrangements made with a local waste hauler and transfer station scale house.
The weekly waste streams for seven schools in East York were also collected and the waste composition was determined. Per capita generation rates for the student body and total staff were computed.

A survey was also conducted to assess the yearly tonnages of white goods and other bulky items generated by residential areas in 10 municipalities in Ontario.

The methods developed and used in this study were found to be cost effective and capable of being used by municipal staff. Recommendations are presented in this volume and in Volume I to further refine and improve the methods used.

Ontario municipalities are encouraged to use the methods demonstrated in this study to satisfy municipal needs, to generate further data on a consistent province-wide basis and to assist in assessing the effectiveness of new waste management programs and identifying trends in waste composition and generation rates.

Recommendations for Further Refinement

Municipalities conducting a waste composition study might consider the following recommendations when designing the sampling protocol and implementing the study methodology.

1) For sampling and sorting convenience, municipalities may choose to conduct the waste composition studies in late spring or mid-fall when refuse odours are less intense and maggots are less frequently encountered. According to Vesling & Rimer (ref. 47), the average residential waste composition does not vary by more than +/- 10% over three quarters of the year. Therefore, aesthetics of the working conditions can be taken into account without risk to obtaining skewed data. The inclusion of yard waste in overall residential waste composition percent profiles should be avoided so that baseline composition percentages are not misrepresented.

2) Municipalities may choose to set up independent collection systems to study the seasonal generation of yard waste and leaves. This would require a coordinated effort between garbage collection personnel, private horticultural firms and other agencies generating and collecting these waste streams.

3) In order to avoid the sampling problems that we encountered with the large apartment buildings in East York, where apparent sampling biases were difficult to avoid, arrangements could be made, for example, with 30 units within the building to participate in a refuse study. This would give a more accurate appraisal of the waste composition in these large apartment buildings. As a check, the method described herein for

obtaining the per capita generation rate for the entire building could then be compared with the per capita generation rate for the 30 units.

4) Municipalities in Ontario should follow the waste composition procedure in conducting their own waste composition analysis, for reasons of consistent data generation using a cost effective approach. Periodically, municipalities should conduct additional waste composition studies to monitor trends in residential waste management and the effectiveness of waste management programs.

SECTION 1

WHY CONDUCT A WASTE GENERATION AND COMPOSITION STUDY

1.0 WHY CONDUCT A WASTE GENERATION AND COMPOSITION STUDY

The waste management challenges facing Ontario communities involve two problems:

1. The need to reduce the amount of waste entering Ontario landfills and incinerators. Many municipalities in Ontario are faced with landfills that are at or near capacity, and building new landfills is a costly and often a political and environmental challenge.

   This challenge is being met in part through the Ontario Ministry of the Environment waste diversion targets. These targets are aimed at reducing waste entering landfills by 25% by 1992, and 50% by 2001. Activities such as residential Blue Box, commercial recycling, waste composting, and recyclable material bans from landfills, and efforts to reduce waste such as excess packaging are being implemented to achieve these objectives.

2. The general societal need to reduce the amount of waste generated on a per capita basis. This need grows greater every day as renewable and non-renewable resources dwindle while population and economies continue to grow.

These two problems require careful consideration and planning by waste managers. If solutions are to be found, these managers will require reliable and current data concerning per capita waste generation rates and percent composition.

By knowing the approximate tonnages involved and the composition of the municipal waste stream, efforts can be made to maximize reduction, reuse and recycling efforts. Per capita generation rates for the total waste stream and for its component parts are needed to correctly design waste management programs and facilities.

1.1 Waste Management Planning

Waste generation information and waste composition data are required for the following reasons:

i) Quantities of waste generated in various neighbourhoods and districts within the municipality must be known to properly assign collection vehicles - therefore a per capita generation rate is needed;

ii) Proper design of waste management facilities such as transfer stations, landfills, recycling depots, composting plants and so on require information concerning the per capita generation rate and waste composition;

iii) When planning for population growth, a per capita generation rate is needed to estimate increases in total waste quantity;

iv) Waste generation rate and waste composition data are needed to assess the effects of waste diversion programs and policies.

1.1.1 Estimation of Total Waste Tonnage

A waste composition study such as the one described herein estimates tonnages of waste generated by every person in the municipality from both residential sources (Part A) and commercial sources (Part B). Waste tonnages can be estimated on a daily, weekly, monthly, or yearly basis. In addition to total tonnage generated, a waste composition study allows an estimation to be made of the tonnage of each material in the waste stream.

1.1.2 Estimation of Tonnage of Recyclable and Recoverable Material

A waste composition study allows accurate estimations to be made of the tonnages of materials being recycled by current recycling programs, the amount of material that could be recovered by those programs (capture rates), and estimates of the amount of material that could be recovered from the waste stream by additional diversion programs.

1.1.3 Estimation of Tonnage of Hazardous Materials

Of concern in the design of landfills and other waste management facilities is the amount of hazardous materials, such as paints, waste oil, used batteries, pesticides, and medical wastes that are found in the waste stream. A waste composition study will provide an estimation of the quantities of these materials present in the solid waste stream.

SECTION 2

WASTE STUDY PARAMETERS AND CONSIDERATIONS

2.0 WASTE STUDY PARAMETERS AND CONSIDERATIONS

Conducting a waste composition and generation study requires careful planning with regard to the type of data required, and how the data will be collected.

2.1 Required Waste Generation Rate and Waste Composition Data

The data collected in a waste composition study fall into two categories:

1. per capita generation rate information;
2. percent composition of the waste by component materials.

2.1.1 Waste Generation Rate

For the purposes of the Ontario Waste Composition Study the residential waste generation rate is defined as kilograms per capita per day (kg/capita/day). These units can easily be multiplied by constants to obtain weekly, monthly, or yearly generation rates in kilograms or tonnes. As well, a total tonnage of waste generated for the municipality can be calculated by multiplying by the total number of persons in the municipality by the per capita generation rate.

2.1.2 Waste Composition

The percent composition of waste by its material components is dependent on the waste stream studied, and on the definition of the categories of material used.

The waste component categories used in the Ontario Waste Composition Study were based in part on the physical or chemical make-up of the component and, in part, on the form the waste material takes. As such there are several subcategories for most materials. The subcategories could be based on physical and chemical make-up, such as those for paper (fine paper, newspaper, corrugated cardboard etc.), or the sub-categories could be based on form and usage such as with ferrous metal (food containers, returnable beverage containers, non-food containers). A list of the

waste component categories and sub categories used in the Ontario Waste Composition Study is given in Table 1.

Note that in Table 1 there are no categories for bulky items such as used appliances and furniture. These items are usually collected separately from regular waste.

The category of yard waste listed in Table 1 is meant to record the quantity of yard waste co-mingled with regular waste. To assess the quantity of leaves and other yard waste collected seasonally such as during fall leaf collection programs of other spring/fall clean-ups additional data collection procedures should be used.

In addition to material composition, the Ontario Waste Composition Study also defined waste by the way in which it was collected and its subsequent destination. As such, composition of Blue Box materials, where present, are analyzed separately from the identical materials found in regular curbside waste, and yard wastes are analyzed separately from the other organic components.

2.2 Income and Housing Basis for Defining Residential Waste Generation

The Ontario Waste Composition Study used the pioneering work of Rathje et al. as a basis for designing the sampling approach and framework (ref. 4,5,6,7,8). Rathje and Thompson (1981) demonstrated during the MILWAUKEE GARBAGE PROJECT the relationship between socio-economic stratification of populations and the composition of residential refuse. Income and housing-type reflect lifestyle and as such influence waste generation.

The methodology of the Ontario Waste Composition Study used an income/housing stratification to describe discrete areas within the municipality called Census of Canada Enumeration Areas, and to select locations for the collection of waste samples.

TABLE 1: WASTE COMPOSITION CATEGORIES

(1) Paper	(a) Newsprint	
	(b) Fine Paper / CPO / Ledger	
	(c) Magazines / Flyers	
	(d) Waxed / Plastic / Mixed	
	(e) Boxboard	
	(f) Kraft	
	(g) Wallpaper	
	(h) OCC	
	(i) Tissues	
(2) Glass	(a) Beer	(i) refillable
		(ii) non-refillable
	(b) Liquor & Wine Containers	
	(c) Food Containers	
	(d) Soft Drink	(i) refillable
		(ii) non-refillable
	(e) Other Containers	
	(f) Plate	
	(g) Other	
(3) Ferrous	(a) Soft Drink Containers	
	(b) Food Containers	
	(c) Beer Cans	(i) returnable
		(ii) non-returnable
	(d) Aerosol Cans	
	(e) Other	
(4) Non-Ferrous	(a) Beer Cans	(i) returnable
		(ii) non-returnable
		(iii) American
	(b) Soft Drink Containers	
	(c) Other Packaging	
	(d) Aluminum	
	(e) Other	
(5) Plastics	(a) Polyolefins	
	(b) PVC	
	(c) Polystyrene	
	(d) ABS	
	(e) PET	
	(f) Mixed Blend Plastic	
	(g) Coated Plastic	
	(i) Nylon	
	(i) Vinyl	
(6) Organic	(a) Food Waste / Rodent Bedding	
	(b) Yard Waste	
(7) Wood		
(8) Ceramics / Rubble / Fiberglass / Gypsum Board / Asbestos		
(9) Diapers		
(10) Textiles/Leather/Rubber		
(11) Household Hazardous Wastes	(a) Paints / Solvents	
	(b) Waste Oils	
	(c) Pesticides/Herbicides	
(12) Dry Cell Batteries		
(13) Kitty Litter		
(14) Medical Wastes		

2.2.1 Knowing Your Community - Census Canada Information

The data required to characterize the income and housing type in a community can be obtained from Census of Canada information for the municipality. The census data is collected every five years and is available from Statistics Canada for a nominal service fee.

Census data is collected in a municipality using discreet areas mapped out by Census Canada called Enumeration Areas (EA). An enumeration area is laid out to encompass an area containing approximately 300 dwellings. As such the geographical area covered varies greatly depending on the density of housing. The EA may be a large rural area, a few city blocks, or one single highrise apartment building.

Enumeration areas were selected as the sampling frame for this study because they are the smallest statistical unit for which census data are available. As such a single EA is likely to have a relatively uniform income level and housing type. These facts allow each enumeration area to be classified into groups based on relatively distinct and real income and housing type strata.

2.2.1.1 Enumeration Areas and the Study Matrix

Census Canada reports the following data for each enumeration area within a municipality: average combine household income; the number of single detached residences, apartments, and other residences; and average number of persons per dwelling. These data are used to create a income/housing matrix for classifying all of the enumeration areas in the municipality. The matrix lay-out is shown in Table 2.

2.2.1.2 Classification of Enumeration Areas By Income

Using the most recent Statistics Canada Census data, each EA in the study community is stratified according to income level. The format for the stratification is as follows:

TABLE 2: INCOME/HOUSING MATRIX USED FOR CLASSIFYING MUNICIPAL POPULATIONS.

Dwelling Type

Income Level	(1) Primarily single Detached Dwellings	(2) Mixed Dwellings	(3) Primarily multiple Dwellings
(A) High	A1	A2	A3
(B) Medium	B1	B2	B3
(C) Low	C1	C2	C3

High Income:	average household income is at least 1/2 standard deviation greater than the mean income for the entire community;
Medium Income:	average household income is no more than 1/2 standard deviation greater than, or less than the mean income for the entire community;
Low Income:	average household income is at least 1/2 standard deviation less than the mean income for the entire community.

Figure 1 illustrates the concept of population stratification by income, described above.

2.2.1.3 Classification of Enumeration Areas By Housing Type

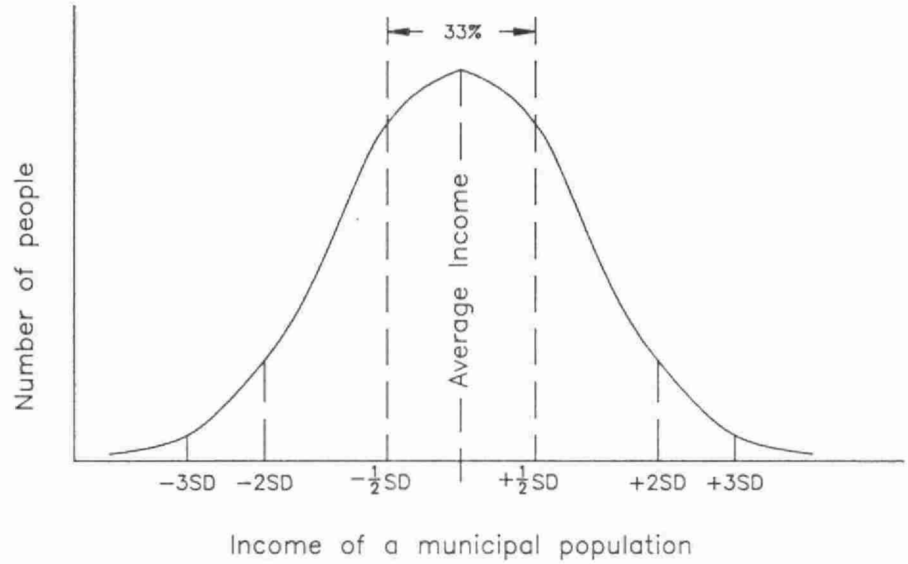
Within each income category, each EA is further classified according to housing type. For each EA, Statistics Canada reports the number of Single Detached residences, Apartments, and Other residences. These numbers, expressed as a percentage of occupied dwellings in the EA are used to identify the predominant housing type for the EA.

Primarily Single Detached:	EAs with 60% to 70% of dwellings reported as "single detached dwellings";
Primarily Multiple Dwellings:	EAs with 60% to 70% of dwellings reported as "apartments" (typically multiple story highrises).
Mixed Dwellings:	EAs with a "mixture" of single detached, apartment buildings with fewer than 30 units, and other dwelling types; having less than 60% of the dwellings listed as single detached or 60% of the dwellings listed as apartments;

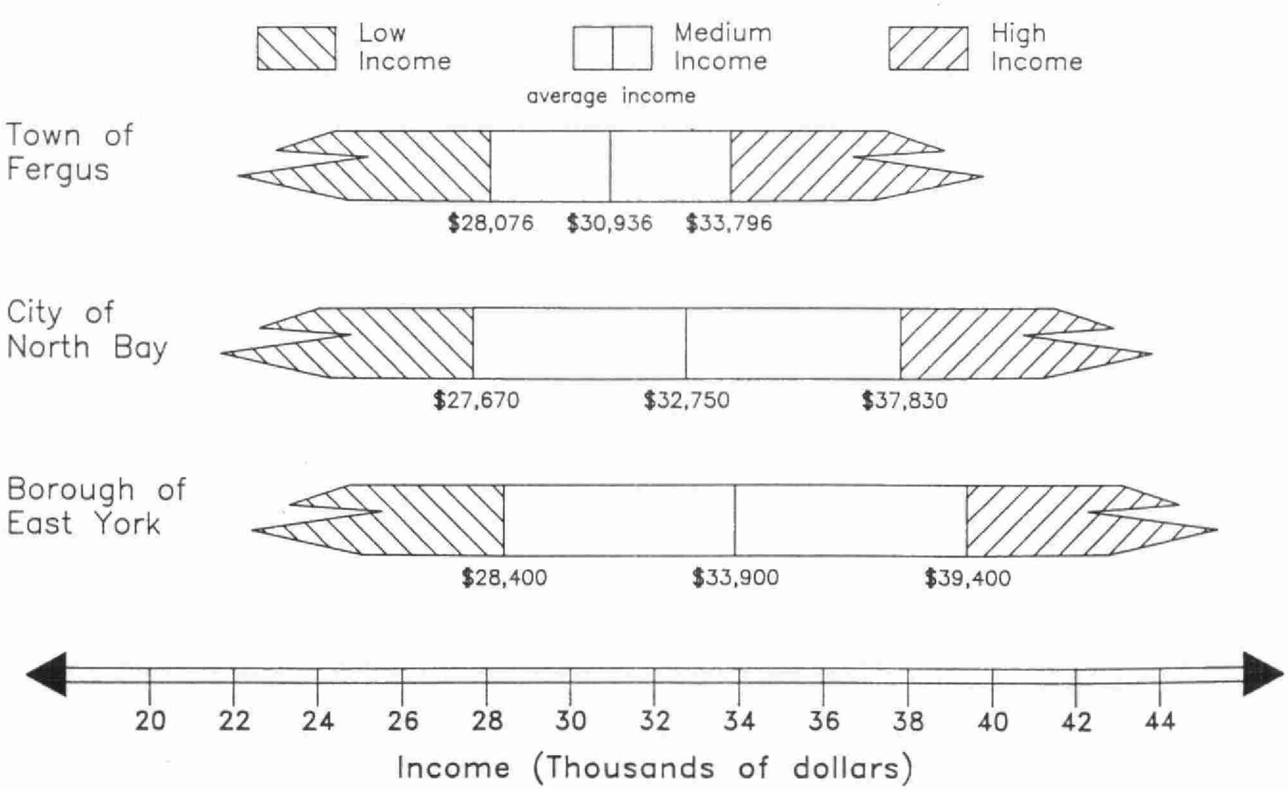
An exact boundary line between dwelling classifications is not rigorously specified in this Study because of the need for flexibility to consider the distribution of the minor components of the residential mix for a particular EA. The distribution of types of residences across the whole municipality should be examined to ensure that

FIGURE 1: CATEGORIZING A MUNICIPAL POPULATION WITH RESPECT TO INCOME:

- THEORETICAL DISTRIBUTION (1A)
- PRACTICAL APPLICATION (1B)



(1A) Idealized representation of normal income distribution over a municipal population. The middle income range extends between −1/2 SD and +1/2 SD and includes 33% of the population.



(1B) Comparison of the low, medium and high income categories for the three municipalities in the Study.

specific cells in the income/housing matrix were not grossly out of proportion to the total number of EAs or the "character" of the municipality.

Once the housing type is determined then each EA can be assigned to its respective cell in the income/housing matrix. Typically a community may have only six or seven of the nine possible income and housing types. This is expected since not all municipalities will have very large multi-story apartment building, or some housing types may not exist for given income strata.

2.2.2 Knowing Your Community - Current Waste Management Practices

The next parameter that must be known before beginning the waste study is the current waste management practices in the municipality.

The following information should be assessed:

1. waste collection frequency: once per week, or twice per week;
2. collection routes and schedules;
3. collection practices and scheduling during holidays etc.;
4. presence of Blue Box programs or other recycling activities and days on which blue box materials are collected;
5. presence of special waste collection programs such as spring and fall clean-up collections, leaf and yard-waste collections, bulky item collection days, white metal collections, hazardous waste collections and so on.

This information is needed to coordinate the collection of waste samples with regular waste collection so that conflicts do not occur, and to ensure that data are collected regarding special waste collections.

2.2.3 Effect of Seasonality On Waste Generation

In any waste composition study there is always the question of seasonality and its effect on waste composition and generation rates. There is a large body of literature

(ref. 1, ref. 9) that suggests if yard waste and leaves are omitted from the calculation of composition and generation rate, the fluctuations in composition and generation rate of household waste are less than 10% over the course of the year. The methodology presented herein treats yard waste and bulky items as separate waste categories, therefore the time of year at which the waste composition study takes place is of secondary consideration. Efforts should be made, however, to assess the tonnages of leaves, yard waste and bulk items generated each year.

2.2.4 Bulk Item and Special Collection Days

Some municipalities have special collections for bulk items, spring and fall clean-up days, and leaf collection programs. These special waste streams need to be assessed individually because they do not fit into to the normal weekly generation of waste by households.

The relatively small number of samples (snap-shot approach) taken when using this methodology precludes taking of any waste that would not be generated on a daily or weekly basis. For a discussion of this problem see Volume I, Residential Waste Composition Study.

2.3 Sampling of Residential Waste

2.3.1 Number of Samples Required in Each Enumeration Area

In the three communities studied as part of the Ontario Waste Composition Study, typically six or seven EAs would be chosen for sampling, corresponding to the income/housing matrix classifications. These EAs form the sampling framework for the study.

Within each enumeration area ten (nine as a minimum) samples of regular curbside residential waste and blue box materials (where present) were taken for analysis. Nine or ten samples were required for statistically accurate results (see Volume I). This number of samples also proved to be the appropriate number for a four or five

person crew to analyze in one week. This allowed the crew to study one EA per week, thus meshing with the existing collection schedules of the communities.

2.3.2 Size of Samples Required

Previous work in waste composition analysis conducted in the United States by Klee and Carruth (1971) indicated that the optimal size of each of the ten samples collected within an EA is 90-150 kilograms (200-300 pounds). As such with an EA the total weight of refuse analyzed would be approximately 1 tonne (1000 kg).

The sample weight of 90-125 kg is for regular curbside waste only. Additional collections of leaves, separated yard wastes, and bulk items will be necessary to assess the total residential waste stream. Inclusions of such materials would skew the analysis in favour of the bulky materials which may be generated infrequently over the year, and hence provide a poor representation of regular waste generation.

SECTION 3

MANPOWER, EQUIPMENT AND COST

3.0 MANPOWER, EQUIPMENT AND COST

The following is a description of the manpower requirements, necessary equipment and costs associated with conducting a waste composition study. In the manpower section a dollar value of the wage for the workers is not specified as this must be determined by the municipality conducting the study. Instead, only an estimation of the number of work days and hours required to complete the study is given. Lists of required and optional equipment is provided, but no dollar amounts for the purchase or rental of this equipment. These details should be carefully considered by any municipality undertaking a waste composition study.

3.1 Field Crew Size Requirements

Four or five people were needed for the waste collection task where a Class 1 Blue Box program exists (for example Town of Fergus; Borough of East York): two truck drivers, one collection data recorder and one (or two) people to pick up the bagged refuse and Blue Box materials. Occasionally, a 5 day work-week was not long enough to complete the collection and sorting operations and an additional work day (Saturday) was required.

In North Bay, where there was no Blue Box program in place, a three member crew carried out the refuse collection. It should be noted that the reduced crew number required that they work an extra full day, i.e., Saturdays, to complete the sorting and weighing of waste.

The field crews for the Ontario Waste Composition Study were comprised of community college students and university graduates. It was emphasized that the Study was really a "laboratory situation". Thus attention was given to organization, routine, reproducibility, consistency--even the cleanliness of garbage cans, van floor etc. This approach attempted to maximize a scientific attitude and thoughtful responsibility leading to careful work habits that the students learn as part of their analytical training. If students are not available, dedicated members of the municipal staff, or other workers could be employed.

In addition to the field crew, a project manager is required. This person must have a technical background and a high level of respect and responsibility within the municipality's works and engineering department. The project leader will be responsible (in the absence of an outside consultant) for performing the calculations necessary to define the income/housing matrix, selecting the EAs for the study, determining the sampling locations, contacting and liaisoning with waste haulers and collectors, ensuring accurate records are kept, and general management of the project.

The Project Manager will in all likelihood be required to generate a report presenting the results of the study. The amount of time required for this task will depend on the purpose for which the study was undertaken.

3.2 Equipment Requirements

The following equipment and hardware is required for the study.

3.2.1 Waste Sample Collection Equipment

The following list of equipment includes rented vehicles and purchased equipment:

- one - 4.3 m.(14 ft.) cube van (for collection of bagged refuse);
- one - pick-up truck (for collection of Blue Box contents);
- one - electronic platform scale (150 kg capacity, Accu Weigh Model PAK-150 (electronic, battery operated scale with digital read-out), Exact Weight Scale, Inc., Toronto, Ontario);
- six - 1.2 m.(4 ft.) x 1.2 m.(4 ft.) x 1.2 m. (4 ft.) heavy duty corrugated containers ("gaylords"); these containers were used for storing the bagged (non-Blue Box) refuse samples as they were being collected;
- four - 1.2 m.(4 ft.) x 1.2 m.(4 ft.) divider frames (2.5 cm. x 5.1 cm. wood furring stock/chicken wire); these were used as horizontal partitions in the back of the cube van for separating the collections of bagged (non-Blue Box) refuse which were stacked on top of each other;

two - 46 cm.(18 in.) x 2.4 m.(8 ft.) divider frames (2.5 cm. x 5.1 cm. wood furring stock/chicken wire); these were used as the two main partitions in the back of the pick-up truck for segregating the collections of Blue Box materials (see Figure 2);

nine - 46 cm.(18 in.) x 41 cm.(16 in.) (approx.) plywood panels; used as partitions in the back of the pick-up truck (see Figure 2);

one - chicken wire "crib": 1.2 m.(4 ft.) x 1.2 m.(4 ft.) x 1.3 cm.(1/2 in.) plywood base; 0.6 m.(2 ft.) high chicken wire and 2.5 cm. x 5.1 cm. furring sides. Nailed to the underside of the crib floor was a square frame which permitted the crib to be centred on the bed of the platform scale (see Figure 3); the crib was used for weighing the refuse as it was being collected from curb-side;

150 - 50.8 cm.(20 in.) x 76.2 cm.(30 in.) x 6 mil polyethylene bags (Oxford Packaging Inc., Mississauga, Ontario); these were used for bagging refuse that was set out loose in garbage cans; the bags were also used for storing refuse samples for moisture and chemical analysis;

40 - 30 litre polyethylene garbage cans; these were used as containers into which sorted refuse was placed (see Figure 4);

one - 2.7 m.(9 ft.) x 3.7 m.(12 ft.) reinforced plastic tarpaulin for covering Blue Box materials in the pickup truck;

six - elastic straps to secure the tarpaulin in place;

one - broad-mouth aluminum shovel; used for cleaning up spills;

one - broom; used for cleaning up spills and sweeping out the vehicles;

one - staple gun and 0.95 cm.(3/8 in.) staples for construction and repair of chicken wire dividers and crib;

one - claw hammer; 5.1 cm.(2 in.) common nails: used in the construction of the crib and divider frames.

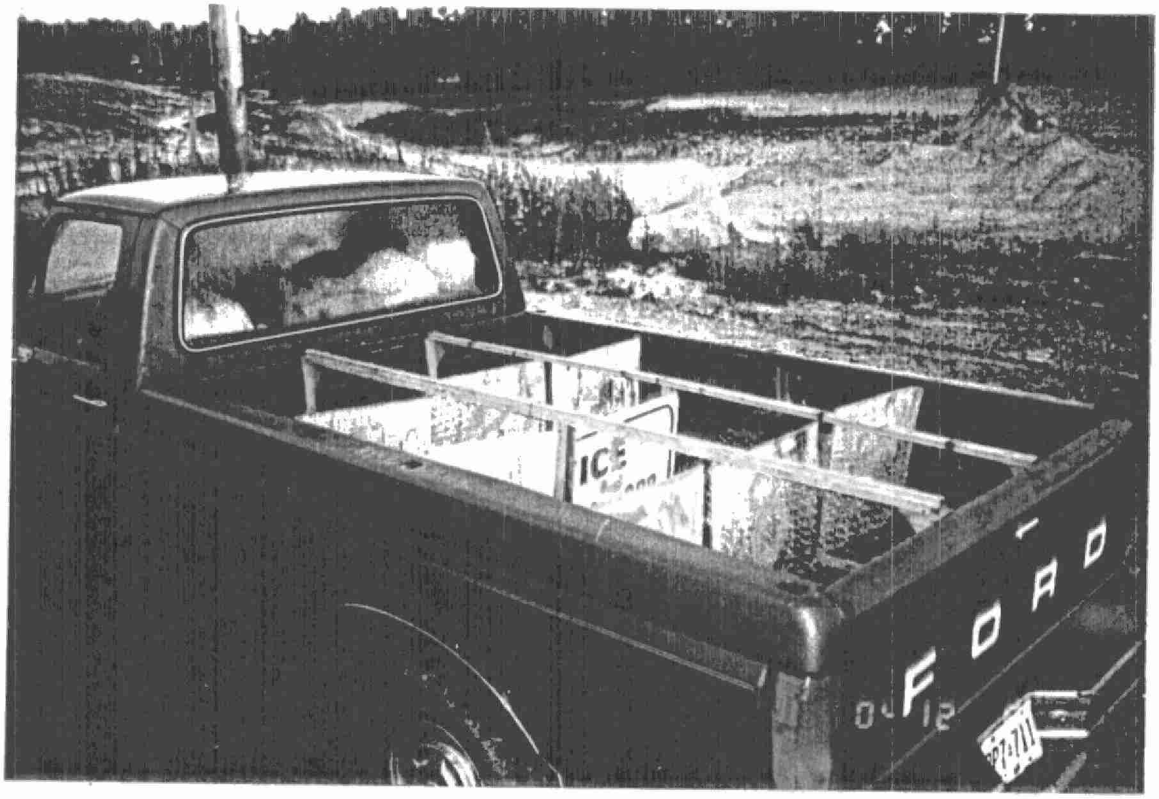


FIGURE 2: PHOTOGRAPH OF PICKUP TRUCK WITH COMPARTMENTS FOR BLUE BOX MATERIALS

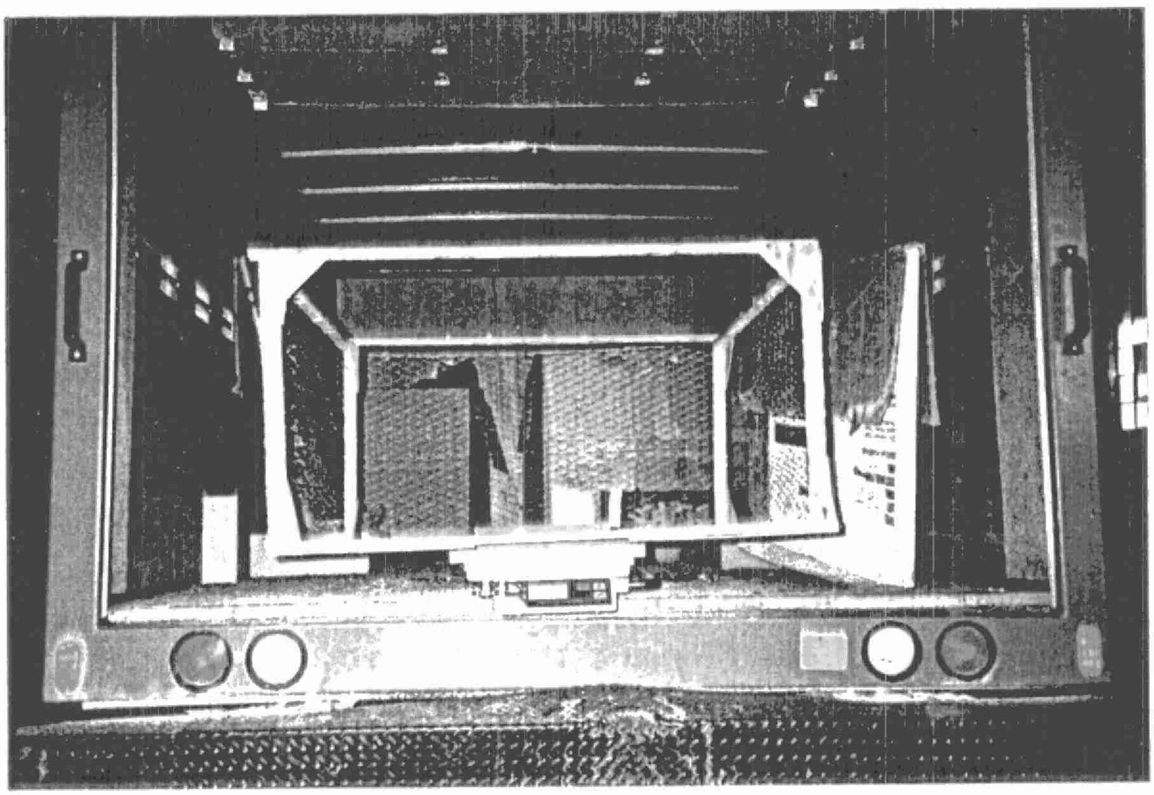


FIGURE 3: PHOTOGRAPH OF CHICKEN WIRE CRIB MOUNTED ON THE PLATFORM SCALE (REAR VIEW OF CUBE VAN)

FIGURE 4: PHOTOGRAPH SHOWING THE POSITIONING OF THE STUDY TEAM AROUND THE TAILGATE SORTING TABLE

3.2.2 Waste Sample Sorting and Measurement Equipment

The following equipment and supplies were needed for the waste sorting and composition analysis:

- 1-150 kg capacity platform scale (noted previously);
- 1-5 kg capacity scale (Accurate model 5000 (electronic, battery operated with digital read-out), Exact Weight Scale Inc., Toronto, Ontario);
- 40-polyethylene garbage cans (note above);
- 1-claw hammer;
- 1-slotted screw driver;
- 1-electrician's pliers;
- 4-magnets
- pairing knives for opening plastic bags
- Personal safety equipment listed below Section 3.2.3

3.2.3 Personal Safety Equipment

Personal equipment required:

- heavy duty, waterproof (PVC-coated) gloves;
- work clothes or coveralls; rubber apron; hat (hard hat if desired)
- steel-toed work boots;
- eye protection (goggles preferable or safety glasses);
- tetanus/polio vaccination (optional: diphtheria, Hepatitis A and Hepatitis B);
- traffic safety vest;
- particle masks, worn by crew members concerned with dust and the possibility of disease transmission;
- anti-bacterial soap, used to clean gloves, hands and face before meal breaks and at the end of the day.

Safety must be stressed at all times during the study including personal hygiene. It is important to remember that within each bag of garbage there may be disease carrying organisms, sharp objects including hypodermic needles, containers that may explode, combustibles, corrosive and caustic agents, harmful chemicals, and dust.

3.2.4 Seasonal Effects on Equipment Requirements - Shelter and Clothing

The season of the year in which the study is conducted has a great bearing on the clothing and shelter requirements of the field crew, and general carrying out of the study.

For several reasons it may be advisable to conduct the study during the fall or winter months. The waste will have less odour and fewer maggots and flies at this time of year. In addition the cool or freezing temperatures will keep the organic fraction of the waste from rotting which will makes the work more manageable from an objective and aesthetic standpoint. The cooler weather will also reduce the amount of moisture lost by the waste, due to evaporation, from the time the sample is collected to the time it is actually sorted (several days in some cases).

If the study is conducted in the autumn or winter months some form of shelter is required by the field crew while sorting the waste. Shelter is required to protect the field crew (and the waste samples!) from wind, rain, snow and cold. During the Ontario Waste Composition Study the following locations were used during the fall and winter study periods. In the Borough of East York, the tipping floor of the former Commissioners Street Incinerator was used. When this location became too cold in December, the sorting location was moved into a heated workshop adjacent to the tipping floor. In North Bay sorting was conducted in a large carnival tent. Heating in the tent was supplied by propane heaters.

In the summer protection from the wind, rain, and direct sun will be required.

In addition to a sheltered work space, the sorting crew must be provided with a warm, dry break-room, and washroom facilities.

3.3 Cost of Conducting a Typical Waste Study

The following is an estimate of the cost associated with conducting a waste composition study.

The length of time required to conduct the residential phase of the waste study is dependent on the number of EAs identified in the income/housing matrix. At most there will be nine EAs to study, although most communities will have fewer since not all cells of the matrix will have representative EAs. In addition to the nine (maximum) EAs identified in the matrix, additional EAs may be studied to confirm the results from the other EAs. Each EA studied requires one week (5-6 days) to complete the sample collection and sorting.

3.3.1 Anticipated Personnel Time Requirements and Costs

STAGE 1: PROJECT INITIATION AND CLASSIFICATION OF ENUMERATION AREAS INTO AN INCOME/HOUSING MATRIX

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Project Initiation	Project Manager[1]	3.0
Task: Obtaining Census Data from Statistics Canada Archive Libraries	Project Manager Project Assistant[2]	1.0 1.0
Task: EA Classification by Income/Housing Types	Project Manager	1.0
Task: Selection of EAs for Inclusion in the Study (Matrix Classification allows for 9 EAs. More may be included in the study as required)	Project Manager	2.25 (0.25 days/EA)
SUB TOTAL:	Project Manager Project Assistant	7.75 1.0
COSTS:	Statistics Canada Service Fee for Materials Travel, Telephone Use, Office Supplies, Computer Time	

[1]The Project Manager will typically be a person from the Municipal Engineering Department or some other member of the Municipal Staff familiar with Waste Management procedures.

[2]The Project Assistant would ideally be a member of the field crew and also a member of the municipal staff familiar with waste management procedures.

3.3.1 Anticipated Personnel Time Requirements and Costs Continued

STAGE 2: DETERMINING SAMPLE POINTS WITHIN THE CHOSEN ENUMERATION AREAS

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Determining Sample Points Within the Selected Study EAs.	Project Manager Project Assistant	4.5 (0.5 days/EA) 2.25 (0.25 days/EA)
SUB TOTAL:	Project Manager Project Assistant	4.5 2.25
COSTS:	Travel (inspection of EAs required), Telephone Use, Office Supplies	

Stage 1 and Stage 2 can be carried out by the Project Manager, or in association with an outside consulting agency familiar with Census of Canada data and sampling procedures.

3.3.1 Anticipated Personnel Time Requirements and Costs Continued

STAGE 3: COLLECTION OF RESIDENTIAL WASTE SAMPLES

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Obtaining/Constructing All Required Equipment and Supplies (See Section 3.2)	Project Manager Project Assistant	3 3
Task: Contacting Municipal/Private Waste Haulers; Contacting Apartment Building Managers; Contacting Other Officials as Required (See Section 6.6)	Project Manager	0.5 days/EA
(A) Once per week municipal waste collection Task: Collection of Waste Sample	Project Manager Field Crew[3]	0.5 days/EA 0.5 days/EA x 4 Persons
(B) Twice per week municipal waste collection Task: Collection of Waste Sample	Project Manager Field Crew	1.0 days/EA 1.0 days/EA x 4 Persons
SUB TOTAL:	Project Manager	3.0 days
(A) Once per week waste collection		
	Project Manager	1.0 days/EA (Field Work)
	Field Crew	0.5 days/EA
(B) Twice per week waste collection		
	Project Manager	1.5 days/EA (Field Work)
	Field Crew	1.0 days/EA
	Project Assistant	2.0

[3] The four (4) person field crew would ideally be composed of persons dedicated to the study and familiar with waste management procedures, and aware of the need for accurate waste management information. The field crew members should have some education in standard laboratory skills such as proper use of scales, accurate record keeping and the necessity of replication of study results. The 4 person field crew may include the project assistant, who could act as a supervisor in the absence of the Project Manager.

3.3.1 Anticipated Personnel Time Requirements and Costs Continued

STAGE 4: WASTE SORTING AND ANALYSIS

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Field Crew Training - Sorting and Classifying Waste; Data Recording Procedures; Safety	Project Manager Field Crew	2.0 1.0 x 4 persons
Task: Waste Sorting	Project Manager Field Crew	1.0 day/EA 5.0 days/EA x 4
SUB TOTAL:	Project Manager Project Manager	2.0 (training) 1.0 day/EA (field work)
	Field Crew Field Crew	1.0 (training) 5.0 days/EA (field work)

COSTS: Equipment purchases and rentals including obtaining shelter for the field crew, provision of safety equipment, and tetanus/polio/diphtheria immunization of the field crew (see Section 3.2) Tipping/disposal fee for sorted waste after analysis Telephone Use, Travel Cost, Office Supplies

Additional Costs associated with optional laboratory analyses such as heating value (BTU) analysis, moisture content and leachable metal content should be included in budget calculation.

Additional time should be allocated for the collection and analysis of yard waste/leaves, white metal goods, and other bulk items. Requirements for a field crew will vary between municipalities and study approaches taken. See section 6.3 and 6.4 for a discussion of approaches to analyzing these waste streams.

3.3.1 **Anticipated Personnel Time Requirements and Costs Continued**

STAGE 5: DATA ANALYSIS AND REPORT WRITING

PROJECT REQUIREMENTS	PERSONNEL	WORK DAYS
Task: Data Entry to Spreadsheets	Project Assistant	1.0 day/EA
Task: Data Analysis, Calculations and Report Writing	Project Manager Project Assistant	10.0 3.0
SUB TOTAL:	Project Manager	10.0
	Project Assistant Project Assistant	1.0 days/EA (data entry) 3.0 (clerical)
COSTS:	Office Supplies, Computer Time	

WORK DAYS TOTAL

Administrative:	Project Manager	26.25
	Project Assistant	9.25
Training Period:	Project Manager	2.0
	Field Crew	1.0 x 4
Field Work:		
(A) Once per week waste collection		
	Project Manager	2.0 days/EA
	Field Crew	5.5 days/EA x 4
(B) Twice per week waste collection		
	Project Manager	2.5 days/EA
	Field Crew	6.0 days/EA x 4

SECTION 4

STAGE 1 - DEFINING THE INCOME/HOUSING TYPE MATRIX

4.0 STAGE 1 - DEFINING THE INCOME/HOUSING MATRIX

As outlined above, the first task of the study is to classify all of the enumeration areas in the study areas (EAs) according to the income/housing matrix. This task defines the sampling framework for the study. The EAs that will be sampled are selected from the matrix cells corresponding to each of the nine possible income and housing types.

4.1 Obtaining Statistics Canada Data

Statistics Canada census data needed for this study can be obtained from the following Statistics Canada library:

Statistics Canada, Toronto
Telephone number:(416) 973-6586
Address: 25 St. Clair Ave. East
Toronto, Ontario
M4T 1M4

Data can be obtained in a printed format or on computer disk or tape. Larger municipalities may find the computer disk format more useful owing to the large volume of data required.

4.2 Municipal Income Stratification

Using the most recent Statistics Canada Census data available, each EA in the study municipality is stratified according to income level. The format for the stratification is:

High Income:	average household income is at least 1/2 standard deviation greater than the mean income for the entire community;
Medium Income:	average household income is no more than 1/2 standard deviation greater than, or less than the mean income for the entire community;
Low Income:	average household income is at least 1/2 standard deviation less than the mean income for the entire community.

To carry-out the classification by income it is necessary to perform the following calculations:

1. calculate the overall mean household income of all EAs in the municipality;
2. calculate the standard deviation of household incomes from the overall mean household income
3. Subtract the average household income for each EA from the overall mean household income for the municipality.
4. Divide the difference of the two means by the standard deviation to determine the number of standard deviations away from the overall mean.

4.2.1 Anytown: Stratifying Income Levels

The stratification of income levels in the fictional town of Anytown is presented in Table 3.

The example classification of EAs in Anytown by income level demonstrates the relationship between the reported average combined household income, the mean household income for the municipality, and the half standard deviation measure.

TABLE 3: ANYTOWN: CLASSIFYING ENUMERATION AREAS BY INCOME LEVEL

ENUMERATION AREA	AVERAGE COMBINED HOUSEHOLD INCOME IN EACH EA	STANDARD DEVIATIONS FROM THE MEAN	CLASSIFICATION
101	$26,010	-0.83	LOW INCOME
102	$22,371	-1.26	LOW INCOME
103	$29,786	-0.38	LOW INCOME
104	$31,851	-0.15	MEDIUM INCOME
105	$34,739	+0.20	MEDIUM INCOME
106	$31,957	-0.13	MEDIUM INCOME
107	$49,655	+1.96	HIGH INCOME
108	$45,726	+1.50	HIGH INCOME
109	$22,246	-1.27	LOW INCOME
110	$35,482	+0.29	MEDIUM INCOME
111	$31,920	-0.13	MEDIUM INCOME
112	$36,728	+0.43	MEDIUM INCOME
113	$31,746	-0.15	MEDIUM INCOME
114	$41,640	+1.01	HIGH INCOME
115	$36,741	+0.44	MEDIUM INCOME

Mean Income of all Enumeration Areas:	$33,906
Standard Deviation of the Mean Income:	7446
Half of the Standard Deviation:	3723

4.3 Municipal Housing Type Characteristics

Each EA is further classified according to housing type. Statistics Canada reports the number of Single Detached residences, Apartments, and Other residences in each EA. These numbers, expressed as a percentage of occupied dwellings in the EA are used to identify the predominant housing type for the EA.

Primarily Single Detached:	EAs with 60% to 70% of dwellings reported as single detached;
Primarily Multiple Dwellings:	EAs with 60% to 70% of dwellings reported as "apartments".
Mixed Dwellings:	EAs with a mixture of single detached, apartment buildings with fewer than 30 units, and "other" dwelling types;

An exact boundary line between dwelling classifications is not rigorously specified in this Study because of the need for flexibility to consider the distribution of the minor components of the residential mix for a particular EA. The distribution of types of residences across the whole municipality should be examined to ensure that specific cells in the income/housing matrix were not grossly out of proportion to the total number of EAs.

4.3.1 Anytown: Classifying Housing Type

The Classification of Housing Type in the fictional town of Anytown is presented in Table 4.

The example classification of EAs in Anytown by housing type level demonstrates the relationship between the percentage of dwelling reported in each of the categories: single detached dwellings, apartments, and other dwellings.

TABLE 4: ANYTOWN: CLASSIFYING ENUMERATION AREAS BY HOUSING TYPE

ENUMERATION AREA	TOTAL OCCUPIED DWELLINGS	NUMBER OF SINGLE DETACHED HOUSES	NUMBER OF APARTMENTS	NUMBER OF OTHER DWELLINGS	CLASSIFICATION
101	305	30 (10%)	200 (66%)	75 (25%)	MULTIPLE DWELLINGS
102	335	10 (3%)	195 (58%)	130 (39%)	MIXED DWELLINGS
103	345	145 (42%)	90 (26%)	110 (32%)	MIXED DWELLINGS
104	240	200 (83%)	5 (2%)	35 (15%)	SINGLE DETACHED
105	345	140 (41%)	0 (0%)	205 (59%)	MIXED DWELLINGS
106	220	0 (0%)	215 (98%)	5 (2%)	MULTIPLE DWELLINGS
107	360	360 (100%)	0 (0%)	0 (0%)	SINGLE DETACHED
108	225	0 (0%)	225 (100%)	0 (0%)	MULTIPLE DWELLINGS
109	325	130 (40%)	80 (25%)	115 (35%)	MIXED DWELLINGS
110	370	350 (95%)	0 (0%)	20 (5%)	SINGLE DETACHED
111	335	190 (57%)	0 (0%)	145 (43%)	MIXED DWELLINGS
112	175	0 (0%)	175 (100%)	0 (0%)	MULTIPLE DWELLINGS
113	220	220 (100%)	0 (0%)	0 (0%)	SINGLE DETACHED
114	300	215 (72%)	0 (0%)	85 (28%)	SINGLE DETACHED
115	325	290 (89%)	10 (3%)	25 (8%)	SINGLE DETACHED

4.4 Allocating Individual EAs to the Matrix Cells

Once each EA has been classified according the relative income level and predominant housing type, the EAs are assigned to the income housing matrix cell they correspond to. This can best be done by sorting the EAs according to their income classification (high, medium, low). Then within each income class sort the EAs according to their housing type classification.

4.4.1 Anytown: Allocating Individual EAs to Matrix Cells

In the example for the fictional town of Anytown, the income/housing classification is shown in Table 5. The matrix cells corresponding to the classifications of High income/Mixed Dwellings, and Low Income/Single Detached Dwellings are not represented. It is not unusual for a municipality to lack representation in one or more matrix cells.

The number of EAs in each classification will be needed for the calculation of the per capita generation rates during the data analysis stage of the study.

4.5 Selecting the Study EAs

Once all of the EAs have been classified it is a simple procedure to select the EAs for inclusion in the study. The EAs should be selected at random, using a random number table where more than one EA is present in a given Matrix cell.

4.5.1 Anytown: Selecting the Study EAs

The classification of EAs in the fictional town of Anytown revealed that the following classes had more than one EA assigned to them: high income/single detached dwellings, medium income/single detached dwellings; medium income/mixed dwellings; medium income/multiple dwellings; low income/ mixed dwellings. From these groups only one EA per classification is needed for the study.

TABLE 5: **ANYTOWN: ALLOCATING INDIVIDUAL ENUMERATION AREAS TO THE INCOME/HOUSING MATRIX CELLS**

ENUMERATION AREA	INCOME / HOUSING CLASSIFICATION
107	HIGH INCOME / SINGLE DETACHED DWELLINGS
114	HIGH INCOME / SINGLE DETACHED DWELLINGS
---	HIGH INCOME / MIXED DWELLINGS
108	HIGH INCOME / MULTIPLE DWELLINGS
104	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
110	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
113	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
115	MEDIUM INCOME / SINGLE DETACHED DWELLINGS
103	LOW INCOME / MIXED DWELLINGS
105	MEDIUM INCOME / MIXED DWELLINGS
111	MEDIUM INCOME / MIXED DWELLINGS
106	MEDIUM INCOME / MULTIPLE DWELLINGS
112	MEDIUM INCOME / MULTIPLE DWELLINGS
---	LOW INCOME / SINGLE DETACHED DWELLINGS
102	LOW INCOME / MIXED DWELLINGS
109	LOW INCOME / MIXED DWELLINGS
101	LOW INCOME / MULTIPLE DWELLINGS

To randomly select the EAs to be used in the study, assign each of the EAs a number. From the random number table select a number for each classification and use the EA with the corresponding number for the study. Table 6 provides an example of how to randomly select enumeration areas for inclusion in the study from a list of several enumeration areas that may fall within a single classification.

Note that for the classification Medium Income/Mixed Dwellings the random numbers 7 and 9 correspond to Enumeration Areas 103 and 111. Either enumeration area could be chosen but by convention the first (random number 7, EA 103) would be used for the study.

TABLE 6: **ANYTOWN: RANDOMLY SELECTING ENUMERATION AREAS TO BE INCLUDED IN THE WASTE COMPOSITION STUDY**

CLASSIFICATION	ENUMERATION AREA	ASSIGNED NUMBER	SELECTED
HIGH INCOME / SINGLE DETACHED DWELLINGS	107	1	
	114	2	YES
MEDIUM INCOME / SINGLE DETACHED DWELLINGS	104	3	
	110	4	
	113	5	
	115	6	YES
MEDIUM INCOME / MIXED DWELLINGS	105	7	YES
	111	8	
MEDIUM INCOME / MULTIPLE DWELLINGS	106	9	YES
	112	10	
LOW INCOME / MIXED DWELLINGS	102	11	YES
	103	12	
	109	13	YES

RANDOM NUMBERS: 2, 7, 9, 11, 6, 13

All other income/housing classifications had one or less enumeration areas assigned to them, and therefore were automatically selected for use in the waste composition study.

SECTION 5

STAGE 2 - SELECTING SAMPLE POINTS WITHIN AN EA

5.0 STAGE 2 - SELECTING SAMPLE POINTS WITHIN AN EA

In Stage 1 the municipality or study area was characterized by enumeration area using an income/housing matrix. From the matrix of income and housing types, one enumeration area per matrix cell was selected at random for study.

Within each chosen EA ten (nine as a minimum) samples must be collected. These samples should be taken so that the samples collected are evenly spread over the entire EA. In addition every household in the EA must have an equal chance of being included in the study.

To achieve these goals ten collection starting points are selected in the EA using a random method. Samples are collected from every house encountered with waste set out for collection while driving along the street(s) containing the starting point until approximately 100 kg of waste is taken. Following the collection of the first 100 kg sample the crew moves on to the next starting point and collects the next 100 kg sample. The process continues until all ten samples have been collected.

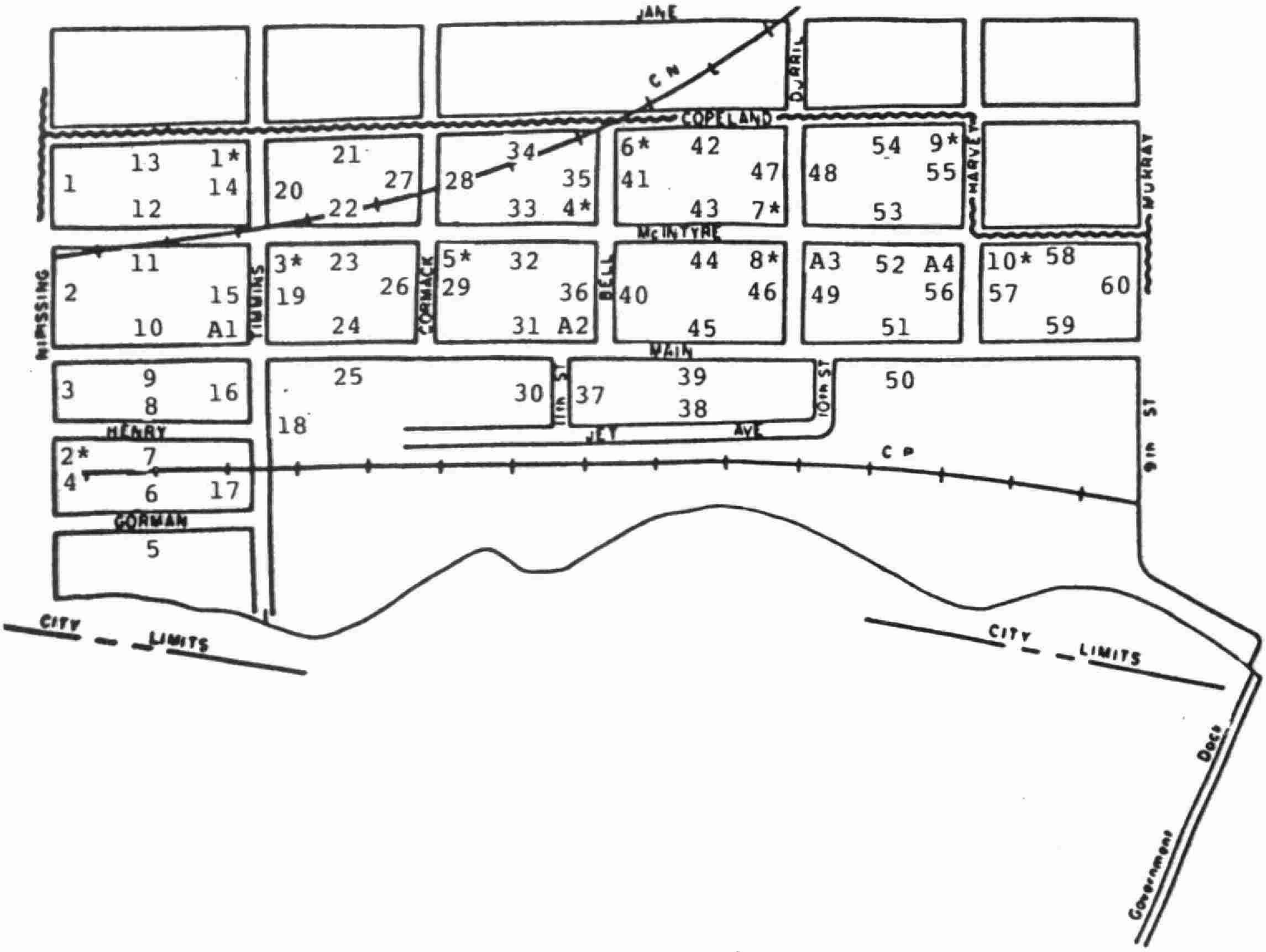
5.1 Street Face Numbering

The first step in selecting the sampling start points is to number each street face in the EA.

By convention, during the Ontario Waste Composition Study, this numbering started in the upper left corner of the EA map (see example Figure 5) and proceeded down and up the page, moving left to right, to the bottom right corner. Every street face was given an individual number.

In addition to the identification of street face starting points, large apartment buildings (10 or more units) in the mixed housing classification should be identified if they exist. These buildings are given a number, like a street face, and may be selected as a sampling location. Buildings of this size will usually generate more than enough waste for one sample.

FIGURE 5: EXAMPLE OF ONE EA SHOWING NUMBERING OF BLOCK FACES AND SAMPLE COLLECTION "STARTING POINTS"



LEGEND

38 STREET FACE

2* COLLECTION STARTING POINT

A3 ALTERNATE STARTING POINT

5.2 Random Selection of Starting Points

Using a random number table ten staring points where selected. By convention collection would start on the street face selected at the eastern, or northern end of the street. In addition to the ten start points selected, three or four alternate start points would also be identified. The need for alternate starting point will be discussed in STAGE 3 - Collection of Waste Samples.

SECTION 6

STAGE 3 -COLLECTION OF WASTE SAMPLE

6.0 STAGE 3 - COLLECTION OF WASTE SAMPLE

Stage 1 described the method used to classify each of the EAs in the municipality, and described the method for selecting EAs to be used in the study. Stage 2 described the method of determining where in the study EAs the samples would be taken from, and outlined the number and size of samples to be taken.

Stage 3 describes in detail the actual sampling of residential waste. Each of the housing types used in the classification of EAs typically has different waste set out practices and collection procedures. These differences require slightly different waste sample collection procedures.

6.1 Regular Curbside Waste

Waste from single detached dwellings, duplexes, houses with apartments, and small apartment buildings is usually set out at the curb by the occupants for collection by the municipal garbage collection brigade. The waste will typically be set out in plastic bags or garbage pails. In addition to regular waste there may be Blue Box Materials, bundles of yard waste, bags of leaves, and items too bulky to be bagged or put in a garbage pail.

6.1.1 Waste Collection Process: Detached Dwellings--General Procedures

The goal of the waste collection process, on any one day, was to obtain 10 (9 as a minimum), 100 kg (minimum weight) samples of residential waste--exclusive of the weight of Blue Box materials and yard waste that were also coincidentally collected if they were placed curbside. This task proceeded as quickly as possible, with a 0700 h start, so that the normal collection of waste and Blue Box items by the municipality was not seriously inconvenienced.

The waste sample collection began at one of the starting points (refer to Figure 5). Waste was collected in front of every dwelling where it was set out, until approximately 100 kg were accumulated in the crib (see Figure 3), some variations to this are noted below. An "en route" collection record was kept of the number of

dwellings that had waste set out: general waste and/or Blue Boxes. Single and duplex dwellings were also indicated.

The importance of the "en route" collection record and the accuracy of the recording of the number of dwellings that were sampled should be noted. The team member who recorded the trip data did not have time to concentrate on any other aspect of the curb-side collection process.

Loose waste set out in garbage cans was rebagged in clear polyethylene bags. These bags were reused and not included in the analyzed waste sample. The collected waste was placed in the chicken wire crib which was mounted on the platform scale on the floor of the van (see Figure 3). The scale was tared with the empty crib on it, prior to filling the crib with waste. When the minimum required weight of waste had been collected (with an allowance for the estimated inclusions of yard waste co-disposed with household waste), the crib was unloaded and the sample was stored in the van. Samples were collected such that no waste was left at the curb.

Corrugated gaylords were used to store six of the waste collections. Two of the remaining collections were piled on top of 1.2 m (4 ft.) x 1.2 m (4 ft.) chicken wire dividers placed on top of the collections in the gaylords. The ninth collection of bagged refuse was piled on top of the Blue Box materials, stored in compartments in the pick-up truck (see below), while the tenth collection was kept in the weighing crib.

Yard waste set out at the curb was weighed at the time of sample collection. The weight was recorded and the yard waste was placed back at the curb for municipal waste collection.

Blue Box items were placed in the corresponding sample compartment in the back of the pick-up truck (Figure 4). There was space for 9 collections in the truck; the tenth collection was stored in polyethylene garbage cans in the van.

It took between 2 and 2.5 hours to make 9-10 collections within an EA. Following the last collection, the contents in the pick-up truck were covered with a tarpaulin.

Elastic straps secured the crib and contents in the back of the van. The Study team proceeded to the base of operations in the municipality and began sorting the samples.

6.1.2 Required Number of Samples

As described above, ten samples (nine as a minimum) are required from each EA. If for various reasons fewer than ten samples are taken, the results for the EA with fewer than ten samples will be reliable but less accurate.

6.1.3 Required Weight of Each Sample

Each of the ten samples taken should weigh 90-125 kg (200-300 lbs). A target weight of 100 kg should be made for each sample with the bias toward larger samples rather than smaller samples. If, for instance, 95 kg of waste have been collected and the next house on the collection route has 10 to 15 kg of waste (typical weight) then that waste should also be taken to guard against weighing errors, loss of materials later on, or other factors which could reduce the weight of that sample.

6.1.4 Collection Equipment Requirements

The following list of equipment includes rented vehicles and purchased equipment:

one - 4.3 m (14 ft.) cube van (for collection of bagged refuse);
one - pick-up truck (for collection of Blue Box contents);
one - electronic platform scale (150 kg capacity, Accu Weigh Model PAK-150 (electronic, battery operated scale with digital read-out), Exact Weight Scale, Inc., Toronto, Ontario);
six - 1.2 m (4 ft.) x 1.2 m (4 ft.) x 1.2 m (4 ft.) heavy duty corrugated containers ("gaylords"); these containers were used for storing the bagged (non-Blue Box) refuse samples as they were being collected;
four - 1.2 m (4 ft.) x 1.2 m (4 ft.) divider frames (2.5 cm x 5.1 cm wood furring stock/chicken wire); these were used as horizontal partitions in

the back of the cube van for separating the collections of bagged (non-Blue Box) refuse which were stacked on top of each other;

two - 46 cm (18 in.) x 2.4 m (8 ft.) divider frames (2.5 cm x 5.1 cm wood furring stock/chicken wire); these were used as the two main partitions in the back of the pick-up truck for segregating the collections of Blue Box materials (see Figure 2);

nine - 46 cm (18 in.) x 41 cm (16 in.) (approx.) plywood panels; used as partitions in the back of the pick-up truck (see Figure 2);

one - chicken wire "crib": 1.2 m (4 ft.) x 1.2 m (4 ft.) x 1.3 cm (1/2 in.) plywood base; 0.6 m (2 ft.) high chicken wire and 2.5 cm x 5.1 cm furring sides. Nailed to the underside of the crib floor was a square frame which permitted the crib to be centred on the bed of the platform scale (see Figure 3); the crib was used for weighing the refuse as it was being collected from curb-side;

150 - 50.8 cm (20 in.) x 76.2 cm (30 in.) x 6 mil polyethylene bags (Oxford Packaging Inc., Mississauga, Ontario); these were used for bagging refuse that was set out loose in garbage cans; the bags were also used for storing refuse samples for moisture and chemical analysis;

40 - 30 litre polyethylene garbage cans; these were used as containers into which sorted refuse was placed (see Figure 4);

one - 2.7 m (9 ft.) x 3.7 m (12 ft.) reinforced plastic tarpaulin for covering Blue Box materials in the pickup truck;

six - elastic straps to secure the tarpaulin in place;

one - broad-mouth aluminum shovel; used for cleaning up spills;

one - broom; used for cleaning up spills and sweeping out the vehicles;

one - staple gun and 0.95 cm (3/8 in.) staples for construction and repair of chicken wire dividers and crib;

one - claw hammer; 5.1 cm (2 in.) common nails: used in the construction of the crib and divider frames.

6.1.5 Twice Weekly Garbage Collection Sampling Protocol

Some municipalities will have twice weekly collection of garbage. In these communities it will be necessary to collect samples on both collection days since the waste sample must reflect the waste generation characteristics of the enumeration

area for the entire week. This presents some problems during sample collection in that a decision must be made regarding the weight of waste to be taken on each sample day.

As an example of this problem staff in the Borough of East York indicated that about 60% of the weekly volume of refuse was placed at curb-side for the first of the two weekly collections, with about 40% set out for the second collection. This ratio was not universally reliable for all of the EAs in the Borough. With a target of 100 kg (minimum weight) of waste that had to be collected for a sample of adequate size, the following collection protocol was developed and illustrated in the example below.

For a given sample, approximately 60 kg of bagged refuse was collected, for example, from 7 houses on the first collection day. Sample collection on the second day started from the same "starting point" assigned on the first day and waste was collected from <u>the same number of dwellings</u>. In theory, the 60/40 relationship would result in approximately 40 kg of refuse collected on the second collection day, for total of 100 kg of waste for the composition analysis.

It is absolutely imperative that waste be collected from the same number of dwellings on the second collection day. Calculation of the per capita generation rate is dependent on knowing the number of dwellings waste was collected from (and average number of occupants per dwelling), and the total weight of refuse collected.

The uncertainty of the 60/40 ratio, required the collection crew to "overcompensate" the weight of the first collection in each sample by picking up more than 60 kg, e.g., 70 kg. This "insurance" weight meant that the crew <u>was required</u> to pick up from 7 dwellings on the second collection day. The sum of two collections would not likely be less than 100 kg.

There were instances in East York where the 60/40 relationship was not accurate. This resulted in either less than 100 kg of waste being collected for the week or a weight greatly in excess of 100 kg being collected. Neither of these occurrences is of great concern so long as they occur infrequently.

Waste collection from apartment buildings with twice weekly collection did not present this kind of a sampling problem (see below).

6.1.6 Recording Number of Houses Passed and Weight of Sample

As note previously, one member of the collection team was assigned the duty of recording information as the sample collection proceeded. The collection record is extremely important later when the per capita generation rate is being calculated.

The sample collection notes must accurately record:
1. Date and time of collection
2. Enumeration area sample
3. Address of "starting point" for each sample
4. Number of houses waste was taken from
5. Number of houses Blue Box materials were collected from
6. Weather conditions (e.g. rain that would wet the sample)

6.2 Blue Box Materials

Blue Box materials are collected along with regular waste, but their weight is not included (initially) in the 100 kg sample taken. Samples of Blue Box materials were stored in the back of the pick-up truck in the compartments constructed out of wood and chicken wire (Figure 2). The number of dwellings setting out Blue Boxes was often different from the number of dwellings regular waste was collected from. It is important to record the number of dwellings blue box materials were collected from for later use in calculating the per capita generation rate and "capture rate" of Blue Box materials.

6.3 Yard Waste and Seasonality

Residential waste from detached dwellings usually contains a certain amount of yard waste (e.g., leaves, grass clippings, brush, etc.) This material can represent a significant proportion of the waste at certain times of the year. The amount of yard

waste will typically be very high in the spring and fall during yard clean-up times, and may also be high during the summer grass growing and gardening times. During the rest of the year very little yard waste is generated.

In a study designed to analyze the composition of residential waste by taking a limited number of samples, it is suggested that yard waste be excluded from the calculation of per capita generation rates and percent composition of residential waste. Depending on the exact time of the study, yard waste may represent too large or too small a proportion of the yearly average generation rate for the municipality. Yard waste generation rates require a long term (yearly) monitoring program to accurately describe their generation rate.

6.3.1 Collection and Analysis of Yard Waste

During collection of residential waste samples, yard waste may be encountered. Where possible, yard waste should be separated at the curbside, weighed, its weight recorded, and returned to the curb. The weight of yard waste should not be included in the 100 kg sample. Bags of refuse suspected of being entirely yard waste should be opened and examined during the collection process. The weight of yard waste is recorded on the composition data sheets but is not included in the per capita generation rate calculation for the reasons stated above.

On occasion yard waste will go undetected at the curbside or is commingled with regular waste. The weight of this material should be recorded at the time of sorting, but will not be used in the calculation of per capita generation rates or percent composition.

6.4 Large and Bulk Items

Large and bulk items present a problem for the sample collection and data analysis. Often a large or heavy item(s) will be placed at the curbside with the regular waste. These heavy items will have the effect of increasing the percent composition of the waste sample toward material component of the large item, and lowering the other

material component percentages. Large heavy items that are clearly not part of the regular waste stream should be excluded from the 100 kg sample.

A statistical basis for this subjective decision is based on the concept of the standard deviation and the normalized "bell curve" of percent composition of waste materials. If the weight of a single item in a sample would cause the percent composition for that material to be greater than three standard deviations from the average percent composition of that material, the item should not be included in the sample. This information is never available in the field, therefore a judgement based on what should be considered "normal" residential waste and what should be included in the sample must be made. A person experienced in waste composition analysis should make this decision.

Large or bulk items are often collected by the municipality on special collection days. These collection days may be weekly, monthly, seasonal (spring/fall), or yearly. For the purposes of determining the per capita generation rates and composition of such materials a yearly monitoring scheme should be set up. This monitoring program could be initiated at the same time as the monitoring program for yard waste since these two waste streams may be linked by collection practices in the municipality.

6.5 Apartment Buildings

During the collection of waste samples, two types of apartment buildings will be encountered that will require special sampling and data collection procedures.

6.5.1 Small Apartment Buildings

In the housing classification of "Mixed Dwellings" the collection crew will often come across small apartment buildings, rooming houses and interconnected dwellings.

Apartment buildings with a small number of units will usually have all the waste set out at the curbside. This waste should be included in the sample, and the number of occupied units in the building recorded.

Larger apartment buildings will often generate enough waste to make up one entire 100 kg sample. Such buildings should be noted during the selection of starting points, and may be selected as sampling locations. The <u>total weight of all refuse</u> set out from the building must be recorded along with the number of occupied dwellings. Any additional waste above the required 100 kg sample size may be returned to the curb to reduce sample sorting time later on.

On occasion waste will not be set out at the curbside, but may be present in a dumpster or storage room. All waste should be removed from the dumpster or storage room and its weight recorded. This activity will require consent of the building superintendent or operator, and such permission should be obtained before the collection begins.

6.5.2 Highrise Apartment Buildings With Dumpsters and Compactors

The housing classification of "Multiple Dwellings" refers to enumeration areas comprised entirely or in part by apartment buildings of 30 or more units. These buildings present several practical problems for the waste study which must be addressed.

1. The ten 100 kg samples should be taken equally from all the dumpsters or compactors, if more than one dumpster is present. This can be achieved by skimming a layer of waste off the top of one dumpster to make up one sample, then moving on to the next dumpster for the next sample. It may be necessary to return to each dumpster more than once to collect all 10 samples.
   Samples of loose waste from broken or compacted bags should be rebagged in 6 mil polyethylene bags.

2. After the ten samples are have been collected the remaining waste must be weighed, and its weight recorded along with the number of occupied dwellings in the building. Weighing of the remaining waste is often best accomplished by contracting a waste hauler to dedicate one truck to pick up the waste from the apartment building, take it directly to a transfer station, and return the weigh scale receipt to the study team.

In the absence of such an arrangement with a private hauler, or where only small amounts of waste remain, the study crew can weigh and record the weight of the waste on the portable scale, and return the excess waste to the dumpster.

6.6 Logistics of Sample Collection

The collection of waste samples and supporting data requires a large degree of co-ordination between the study team, Ministry of the Environment officials, municipal authorities and staff, building owners, waste haulers and others.

6.6.1 Documents and Meetings

Two important documents must be obtained from the Ministry of the Environment, Waste Management Branch. The first authorizes the collection of waste for the Waste Composition Study; the second is a letter to be given to any individual in the municipality who is interested in learning more about the residential study.

The procedure to obtain Ministry approval for solid waste sample collection by municipalities undertaking waste composition studies, is as follows:

A letter requesting Ministry approval for temporary collection of solid waste samples shall be mailed by the interested municipality to:

Mr. Dave Crump
Operations Coordinator
Operations Division
Ministry of the Environment
14th Floor, 135 St. Clair Ave., West
Toronto, Ontario
M4V 1P5

The letter shall include, but not be limited to the following type of information:

- Background and reasons for undertaking the study.
- Study objectives.
- Study approach.

- Contractor's name.
- Collection area.
- Approximative number of samples to be collected.
- Approximative weight of each sample.
- Estimated duration of the project.

A high level of coordination is required between the Study Project Manager, municipal staff and waste haulers to ensure scheduling of refuse collections. Each week, a map of the EA scheduled for inclusion in the refuse study should be delivered to municipal staff and/or the waste haulers.

The study team must be informed of the regular collection day in the study enumeration area, whether there is once or twice weekly collection, the ratio between first and second day set-out rates (e.g. 60/40 spilt) when there is twice weekly collection, and any other potential collection problems such as rescheduling at holiday times.

The municipal waste collection crews should be directed away from the study area for at least three hours to allow the study team to collect samples.

A similar level of coordination is required in order to obtain permission to include small and large apartment buildings in the Study. Usually the details can be arranged through phone conversations with apartment owners and building managers and waste haulers, but occasionally written requests for permission are required.

In North Bay, a press release was issued by the City to inform its residents about the City's participation in the Ontario Waste Composition Study. This may be helpful in facilitating the collection crew's activities.

SECTION 7

STAGE 4 - WASTE SORTING AND ANALYSIS

7.0 STAGE 4 - WASTE SORTING AND ANALYSIS

Stage 4 describes the methods to be used by the study team to analyze the waste samples after they have been collected. These analyses include sorting the waste into its material components and weighing each material, determining moisture content, and optional analyses such as BTU (heating value analyses) and metal content.

7.1 Sorting Location

Samples of waste are returned to a central location where sorting and weighing can take place. The sorting location varied with the municipality being studied and the seasonal weather. In general the sorting location had to be large enough to allow the sorting team to set up a work table and an array of plastic buckets, and should provide some protection from the elements.

In the Town of Fergus, sorting was conducted at the Guelph Landfill Site. No shelter was provided except for a large tarpaulin which was used as a sun-screen during the hot summer months.

In Borough of East York sorting was conducted on the tipping floor of the former Commissioners Street Incinerator. This location provided adequate protection from the wind and cold during the months of November and December. On very cold days the work was moved into a heated work room adjacent to the tipping floor.

In the City of North Bay sorting was carried out in a large (20 ft. by 20 ft.) carnival-type tent. The study took place during the month of February, during which times temperatures were continually well below freezing. The tent was heated with two 15,000 BTU propane heaters.

7.2 Sorting Equipment and Set-up

Sorting of waste samples was conducted on a large wooden table around which all of the sorting team could stand. The table was constructed out of one inch plywood sheets, supported either by the tail-gate of the pick-up truck or on saw horses (see Figure 4).

The sorting team position themselves around the table and set up the array of plastic sorting buckets (30 litre plastic garbage cans) into which the various components of the waste are sorted (see Figure 4).

The sorting buckets are arranged to promote the idea of "handedness". To begin with, a bucket for putrescibles which is placed directly in front of each sorter. This provides the least amount of handling for the largest component by weight, and the most difficult component to handle.

Each sorter then shares a bucket for each of the other components with either the sorter on the right or on the left. For example, the buckets could be arranged so that a sorter is placing all paper categories to the left side and all plastic categories to the right side. Buckets for the larger and heavier objects can be placed behind the sorters, at a further distance but should be shared by two or more sorters. This arrangement of buckets allows the sorters to pick up an item and deposit it in the correct bucket without having to transfer the object from hand to hand, once the idea of " handedness" is established.

Additional equipment required for the sorting procedure includes:

- 150 kg capacity platform scale (noted previously);
- 1.5 kg capacity scale (Accurate model 5000 (electronic, battery operated with digital read-out), Exact Weight Scale Inc., Toronto, Ontario.);
- 40 polyethylene garbage cans (noted above);
- 1 claw hammer
- 1 slotted screw driver;
- 1 electrician's pliers;
- 4 magnets
- paring knives for opening plastic bags
- personal equipment listed Section 7.6.6

7.3 Waste Component Categories

The samples of waste are sorted into the categories shown in Table 7. The categories were listed on data collection sheets which allowed the weight of each component to be recorded opposite of it. Space should also be available on the data sheet for recording of miscellaneous items that do not fit the predetermined categories. The information recorded on the data collection sheet for each sample can then be transferred directly to computer spreadsheets for analysis.

Notes On the Categories

While sorting/classifying the waste samples certain items, such as a glass bottle, are simple to categorize. Some waste materials may be composed of several different materials in layers or otherwise combined which makes identification difficult. Other waste materials, due to their unique physical or chemical structure, will not fall into obvious categories. The degree and level of detail to which the Ontario Waste Composition Study waste material categories have been subdivided reflects an effort to deal with these sorting problems.

In general, if a material could be identified by a unique identifying keyword or phrase in addition to its generic material composition, that descriptor formed the basis for its classification. The generic categories of paper, glass, ferrous metal, non-ferrous metal, plastics and organics each have several subcategories. In addition several unique categories are used such as diapers (disposable), dry cell batteries, kitty litter, and medical waste are used.

TABLE 7: WASTE COMPOSITION DATA COLLECTION SHEET

Town:
Enumeration Area:
Collection Dates:

(1) Paper (a) Newsprint				
(b) Fine Paper / CPO / Ledger				
(c) Magazines / Flyers				
(d) Waxed / Plastic / Mixed				
(e) Boxboard				
(f) Kraft				
(g) Wallpaper				
(h) OCC				
(i) Tissues				
(2) Glass (a) Beer (i) refillable				
(ii) non-refillable				
(b) Liquor & Wine Containers				
(c) Food Containers				
(d) Soft Drink (i) refillable				
(ii) non-refillable				
(e) Other Containers				
(f) Plate				
(g) Other				
(3) Ferrous (a) Soft Drink Containers				
(b) Food Containers				
(c) Beer Cans (i) returnable				
(ii) non-returnable				
(d) Aerosol Cans				
(e) Other				
(4) Non-Ferrous (a) Beer Cans (i) returnable				
(ii) non-returnable				
(iii) American				
(b) Soft Drink Containers				
(c) Other Packaging				
(d) Aluminum				
(e) Other				
(5) Plastics (a) Polyolefins				
(b) PVC				
(c) Polystyrene				
(d) ABS				
(e) PET				
(f) Mixed Blend Plastic				
(g) Coated Plastic				
(i) Nylon				
(i) Vinyl				
(6) Organic (a) Food Waste / Rodent Bedding				
(b) Yard Waste				
(7) Wood				
(8) Ceramics / Rubble / Fiberglass / Gypsum Board / Asbestos				
(9) Diapers				
(10) Textiles/Leather/Rubber				
(11) Household Hazardous Wastes (a) Paints / Solvents				
(b) Waste Oils				
(c) Pesticides/Herbicides				
(12) Dry Cell Batteries				
(13) Kitty Litter				
(14) Medical wastes				
(15) Miscellaneous				
(16) BLUE BOX ITEMS (a) Newsprint				
(b) Liquor / Wine Bottles				
(c) Food Jars / Other Bottles				
(d) Food Cans (i) ferrous				
(ii) non-ferrous				
(e) Beer Cans (i) ferrous				
(ii) non-ferrous				
(iii) American				
(f) Pop Cans (i) ferrous				
(ii) non-ferrous				
(g) PET Bottles				
(h) Plastic Jugs				
(i) OCC				

When an item was found to be composed of several materials, the most predominant material by weight was used as the basis for classification. For example a paper container with a thin coat of plastic would be classified as waxed/plastic/mixed paper (item **1d**). Similarly a plastic bag with a thin aluminum foil liner (potato chip bags) would be classified as coated plastic (item **5g**).

Dr. Fred Edgecombe, Executive Director, EPIC (**E**nvironment & **P**lastics **I**nstitute of **C**anada) recommended that all polyethylene and polypropylene containers and film plastics be grouped together as "polyolefins" (item **5a**), rather than trying to distinguish between polyethylene of different densities and crystal linearity. A small amount of SARAN wrap (polyvinylidene chloride) would also have been included in this category.

The PVC category (item **5b**) was restricted to rigid containers; the vinyl category was reserved for other materials such as scraps of vinyl siding.

A simple "smoke and drip" test, provided by Dr. Edgecombe, was used to assist in determining the category for a particular plastic item. The test is included as Appendix D of Volume I, but it should **not** be viewed as a definitive qualitative method when used by itself and the test is not presented in this report. The sorting team should receive training from a person knowledgable in distinguishing plastic types during their general job training.

Mixed blended plastics (item **5f**) were used to classify plastic packaging around meat products. Coated plastics (item **5g**) were used to classify packaging in which the plastic portion was judged to be the greatest percentage by weight, e.g., potato chip bags. The "Tetrapak" boxes were categorized as mostly paper (boxboard) and included in item **1d**.

Rodent bedding (item **6a**) was routinely encountered in small quantities of urine-soaked cedar shavings and faecal pellets. The material was included in the food waste category because of the putrescible nature of both of the components. Likewise, individual "packages" of canine excreta--presumably contributed by citizens obeying the "poop-and-scoop" statutes--were included in this category. Kitty litter

(item **13**) was more frequently encountered and because of the inorganic nature of the granular product was given a single, separate category.

Sanitary napkins were included in the paper subcategory of tissues (item **1i**).

Medical wastes (item **14**) included medicines, insulin bottles and associated used syringes (needles protected and unprotected) and syringes without accompanying evidence of medicinal application.

Aerosol cans were collectively weighed and included in the ferrous section as item **3d**. At the time, we felt that one category for ferrous/non-ferrous pressurized containers would be adequate owing to the small number of non-ferrous aerosol containers. An additional category for non-ferrous aerosol containers may be incorporated into the sorting routine.

7.4 Weighing Sorted Waste - Use of Tared Buckets and Electronic Scales

After sorting, each material can be weighed in its bucket. The electronic platform scale (150 kg capacity) should be "tared" with an empty bucket so that the scale reads only the weight of the material in the bucket. Scale tare should be checked frequently to ensure that the scale is operating properly. One person can be designated as the data recorder, while the remainder of the crew load the scale, and empty the buckets that have been weighed.

Often there will be several small items that are too small to be weighed on the 150 kg capacity platform scale. These small items should be weighed separately on a smaller (1.5 kg capacity) scale.

7.5 Use of Standard Data Sheets - Recording Weights

Standardized data recording sheets such as shown in Table 7 should be used to record all weights. The sample being analyzed, the enumeration area from which it was taken, and the date of sorting should be clearly indicated on each sheet. If one person acts as the designated record keeper, fewer mistakes and omissions are likely to occur.

7.6 Personnel Training - Safety

During the sorting exercise several safety precautions should be taken. Safety includes proper handling of the waste samples, protective clothing, hygiene, and immunization. With limiting the generality of safety requirements, several comments regarding safety are made.

7.6.1 Waste Handling

When handling waste the collection crew and sorters must be aware of sharp and pointed objects, corrosive and caustics chemicals, hazardous and poisonous chemicals, and potential disease carrying objects such as dead animals, insects, medical waste and so on. Careful and watchful work will allow workers to spot these items and avoid coming into contact with them.

7.6.2. Protective Clothing, Hygiene, and Immunization

All members of the collection and sorting crew should dress appropriately for the work conditions, and wear the proper protective equipment. Personal equipment includes:

- heavy duty, water proof (PVC coated) gloves;
- work clothes (pants and long sleeve shirts) or coveralls; rubber apron, hat;
- steel toed work boots;
- eye protection;
- tetanus/polio vaccination (optional: diphtheria, Hepatitis A and Hepatitis B);

- traffic safety vest
- particle masks, worn by crew members concerned with dust and the possibility of disease transmission;
- anti-bacterial soap, used to clean gloves hands and face before meal breaks and at the end of the day.

Efforts should be made to maintain personal hygiene during sorting, as this will reduce any possible disease transmission. Contact with eyes, ears and mouth should be avoided until hands and face have been thoroughly washed with anti-bacterial soap.

7.7 Moisture Content Analysis - Optional

Analysis of moisture content is optional for the purposes of this study, but is useful when comparing percent composition and per capita generation rates between enumerations, during different seasons, and between different years. The moisture content of the waste allows you to identify samples that may be very wet or very dry, and hence have a greater or lesser weight than expected. Samples of waste should be analyzed as soon after collection and sorting to reduce the amount of moisture transfer taking place.

After the waste sample has been sorted into the designated categories and weighed, samples of plastics, paper, food waste, disposable diapers, and textiles are placed in large polyethylene bags, folded and stapled shut, and transported to a drying laboratory. The contents of the bags are weighed, and placed in a waste drying oven at 95 C for 48 hours. The samples are reweighed after the 48 hour period to determine the weight loss due to evaporation of moisture.

7.8 Other Optional Analyses - BTU, Leachable Metals

Other analyses were undertaken during the Ontario Waste Composition Study which may include determining the heating value of the waste by assessing its BTU value, and determining the leachable metal content of various waste components. Results

of the BTU analysis and heavy metal content of vacuum cleaner bag dust are presented in Volume I.

7.9 Yard Waste Data Collection

During collection of waste samples, yard waste (leaves, grass clippings, tree trimmings) should be omitted from the 100+ kg sample. When yard waste is encountered at the curb its weight should be recorded, and the yard waste returned to the curb. The total weight of yard waste found in the sorted waste and the weight of yard waste weighed and returned to the curb during sample collection is recorded on the data collection sheets, but the weight of yard waste is not included in the calculation of the percent composition of waste.

SECTION 8

STAGE 5 - DATA ANALYSIS AND MANIPULATION

8.0 STAGE 5 - DATA ANALYSIS AND MANIPULATION

Data collected in Stage 3 and Stage 4 must be summarized and analyzed. This section describes the calculations necessary to determine the per capita generation rate (kg/capita/day), and the percent composition of residential waste.

8.1 Using a Computerized Spreadsheet to Summarize Data

For the Ontario Waste Composition Study, Gore & Storrie Limited created a computerized spreadsheet to calculate and summarize percent composition for each 100 kg sample and each enumeration area. Similar data spreadsheets can be created for each community.

The Gore & Storrie spreadsheets are designed such that the data entry operator enters the weight of each waste component recorded during the sorting procedure, and the computer calculates:

- percent composition of each waste component in the 100 kg sample;
- average percent composition for the enumeration area;
- average weight of each waste component in the 100 kg sample;
- standard deviation of the average percent composition and average weight of each waste component;
- standard error of the average percent composition and average weight of each waste component.

Computerized spreadsheets can be printed out in report format if needed.

8.1.1 Percent Composition of Waste

Percent composition is calculated by dividing the weight of each sorted material (MATERIAL WEIGHT) by the sum of the material weights (TOTAL WEIGHT), and expressing the result as a percent.

MATERIAL WEIGHT ÷ TOTAL WEIGHT x 100% = PERCENT COMPOSITION

The percent composition of each component of the waste stream is only relevant if an estimate of the per capita generation rate (kg/capita/day) of waste is available. The per capita generation rate of all wastes (calculation of which is described in Section 8.2 below) combined with the percent composition of waste allows an estimation to be made of the tonnage of each component generated by the municipality. Reporting the percent composition of the waste stream, without reporting a total tonnage figure or per capita generation rate for the municipality is meaningless.

8.2 Calculation of Per Capita Waste Generation Rate

Calculation of per capita generation of residential waste requires the following:
Per capita generation rate of waste is calculated based on the number of dwellings waste is collected from, the average number of persons per dwelling, the weight of waste collected, and the number of days over which the waste was generated.

Refer to Table 8 for an example of per capita generation rate calculation.

TABLE 8: **SAMPLE CALCULATION OF THE PER CAPITA GENERATION RATE IN AN EA. DATA FROM THE FICTIONAL TOWN OF ANYTOWN, EA # 107**

Town: Anytown
EA: 107 / High Income; Primarily Single Detached Dwellings
Pop: 1020
Dwellings: 360
PPD: 2.83

Sample Number	Dwellings with Refuse	Dwellings with Blue Boxes	Sampled Refuse Weight (kg)	Sampled Blue Box Weight (kg)	Daily Weight /Dwelling (kg/day)	Waste /person /day (kg)	S.E.
31	8	5	115.80	31.11	2.51	0.887	
32	11	5	96.39	26.38	1.63	0.576	
33	6	3	123.52	24.30	3.52	1.244	
34	8	7	96.82	39.50	2.13	0.753	
35	12	8	103.06	45.80	1.64	0.580	
36	9	7	113.69	37.20	2.18	0.770	
37	2	2	42.12	40.36	4.45	1.572	
38	5	5	89.83	15.58	2.79	0.986	
39	7	4	122.68	12.65	2.73	0.965	
40	11	6	141.71	22.39	2.11	0.746	
Sample Ave.	7.9	5.2	104.56	29.53	2.57	0.908	0.097

8.2.1 Municipalities with Blue Box Recycling

In communities with Blue Box recycling programs calculation of the per capita generation rate of waste requires determining the generation rate of regular waste, and the generation rate of Blue Box materials. This presents a minor problem in that the households do not usually set their Blue Box out every week. The Blue Box is normally only set out when it is full. The time for the blue box to fill up may be one, two or more weeks, therefore some estimate of the put-out rate or timing set out of blue boxes must be made.

It is erroneous to assume that Blue Boxes are set out each week. Making this assumption will cause the per capita generation rate of all wastes to be too high, and will give false information regarding the effectiveness or capture rate of the Blue Box program. Accurate estimates of the typical put-out rate can only be made by carefully monitoring the Blue Box program. The persons riding the collection trucks may have valuable insight into the put-out frequency in the municipality or even the enumeration area being studied.

Calculation of generation rate proceeds as follows:

- Determine the total sample weight (WASTE WEIGHT) of waste collected (for each 100+ kg sample). These data are recorded in the trip note book.
- Determine the number of dwellings (DWELLINGS) waste was collected from to achieve each 100 kg sample. These data are recorded in the trip notebook.
- Determine the total weight of Blue Box (BLUE BOX WEIGHT) material collected (for each 100+ kg sample).
- Determine the number of dwellings Blue Boxes (BLUE BOXES) recyclable material was collected from. These data are recorded in the trip notebook.
- Determine, by consultation with municipal officials, the typical put-out rate of Blue Boxes (PUT-OUT RATE). For example, Blue Boxes may be put out every two weeks by the residents, as opposed to weekly. Therefore the PUT-OUT RATE is once every 14 days
- Determine the average number of persons per dwelling (PPD) from the Census information
- The daily weight of waste generated by each <u>dwelling</u> is calculated:

(WEIGHT (kg) ÷ DWELLINGS ÷ 7 (days)) +
(BLUE BOX WEIGHT (kg) ÷ BLUE BOXES ÷ PUT-OUT RATE (days)) =
DAILY WEIGHT/DWELLING (kg/dwelling/day)

- The <u>per capita generation rate</u> is calculated:

  DAILY WEIGHT/DWELLING ÷ PPD = WASTE/PERSON/DAY (kg/capita/day)

8.2.1.1 Anytown: Calculation of Per Capita Generation Rate of Waste

In Anytown, enumeration area 107 was studied as part of the waste composition study. The data and calculations for the average per capita generation rate in enumeration area 107 are shown in Table 8.

In Anytown it was determined that Blue Boxes were set out by the residents every two weeks, for a put-out rate of 14 days (PUT-OUT RATE = 14 days). Ten samples of regular household waste and Blue Box Materials were collected in enumeration area 107.

For sample number 31, the calculation of the per capita generation rate is as follows (see Table 8). Note that regular waste was collected from 8 dwellings, while Blue Box material was collected from only 5 dwellings.

- The daily weight of waste generated by each <u>dwelling</u> is calculated:

  (WEIGHT (kg) ÷ DWELLINGS ÷ 7 (days)) +
  (BLUE BOX WEIGHT (kg) ÷ BLUE BOXES ÷ PUT-OUT RATE (days)) =
  DAILY WEIGHT/DWELLING (kg/dwelling/day)

  (115.80 kg ÷ 8 DWELLINGS ÷ 7 days) +
  (31.11 kg ÷ 5 DWELLINGS ÷ 14 days) = 2.51 kg/dwelling/day

- The <u>per capita generation rate</u> is calculated:

  DAILY WEIGHT/DWELLING ÷ PPD = WASTE/PERSON/DAY (kg/capita/day)
  2.51 kg/dwelling/day ÷ 2.93 persons/dwelling = 0.857 kg/capita/day

8.2.2 Municipalities With No Blue Box Recycling

In the absence of Blue Box recycling the calculation of the per capita generation rate is much more simple. The estimation involved in determining how many days or weeks blue box materials are accumulated over before being set out for collection is not required.

Calculation of the per capita generation rate proceeds as follows.

- Determine the total sample weight (WASTE WEIGHT) of waste collected (for each 100+ kg sample). These data are recorded in the trip note book.
- Determine the number of dwellings (DWELLINGS) waste was collected from to achieve each 100 kg sample. These data are recorded in the trip notebook.
- Determine the average number of persons per dwelling (PPD) from the Census information
- The daily weight of waste generated by each <u>dwelling</u> is calculated:

  (WEIGHT (kg) ÷ DWELLINGS ÷ 7 (days)) =
  DAILY WEIGHT/DWELLING (kg/dwelling/day)

- The <u>per capita generation rate</u> is calculated:

  DAILY WEIGHT/DWELLING ÷ PPD = WASTE/PERSON/DAY (kg/capita/day)

8.2.3 Estimation of a Weighted Generation Rate for the Municipality

The average per capita generation rate for the enumeration area is calculated by taking the mean of the per capita generation rates of each of the 100+ kg samples taken. The average per capita generation rate for each enumeration area studied is then used to estimate the overall weighted generation rate for the municipality.

In the municipality there may be one or more enumeration areas assigned to each income/housing classification type. The number of enumeration areas in each cell of the income/housing matrix, expressed as a percentage of the total number of enumeration areas in the municipality, acts as the weighting factor for the calculation of the weighted per capita generation rate.

The calculation is as follows:

- Determine the average per capita generation rate (AVERAGE WASTE/PERSON/DAY) (kg/capita/day) for the each income/housing type classification from the enumeration areas studied.
- Determine the number of enumeration areas in each income/housing classification matrix cell, expressed as a percentage (PERCENT) of the total number of enumeration areas in the municipality.
- AVERAGE WASTE/PERSON/DAY x PERCENT = WEIGHTED PER CAPITA GENERATION RATE

8.2.3.1 Anytown: Calculation of the Weighted Per Capita Generation Rate

Table 9 shows the calculation of the weighted per capita generation rate for the entire town of Anytown. Each of the cells of the income/housing classification matrix has been assigned a "weight" based on the number of enumeration area falling into that cell.

The calculation of the weighted per capita generation rate is as follows.

WEIGHTED PER CAPITA GENERATION RATE (kg/cap/day)

```
Weighted Sum of          |    waste     |     |     EAs in the cell as     |
Cells A1-C3 in       =   | generation   |  x  |percentage of total number|
income/housing           |  rate in a   |     |of EAs in the municipality|
    matrix               | matrix cell  |     |   (for Study purposes)    |
```

8.3 Waste Component Generation Rate

The percent composition of waste is only meaningful given an estimate of the per capita generation rate of waste for the municipality. To determine how many kilograms or tonnes of a certain material are generated (GENERATED) in an enumeration area, or the municipality, over a set time period the percent composition

TABLE 9: RESIDENTIAL WASTE GENERATION DATA INCORPORATED INTO THE INCOME/HOUSING MATRIX TO ESTIMATE THE WEIGHTED PER CAPITA GENERATION RATE (KG/CAPITA/DAY) FOR THE FICTIONAL TOWN OF ANYTOWN.

	(1) Primarily Single Detached	(2) Mixed Dwellings	(3) Primarily Multiple Dwellings
(A) High Income	0.908 (13.3%)	0 (0%)	0.867 (6.7%)
(B) Medium Income	0.879 (26.7%)	0.811 (20.0%)	0.622 (13.3%)
(C) Low Income	0 (0%)	0.798 (13.3%)	0.783 (6.7%)

Weighted per capita generation rate (kg/capita/day) = 0.817

(PERCENT) of that material is multiplied by the per capita generation rate (GENERATION RATE) estimated for the enumeration area, or for the municipality.

- PERCENT (%) x GENERATION RATE (kg/capita/day) = GENERATED (kg/capita/day)

SECTION 9

ANALYSIS OF WASTE FROM SCHOOLS & OTHER INSTITUTIONS

9.0 ANALYSIS OF WASTE FROM SCHOOLS & OTHER INSTITUTIONS

9.1 Per Capita Waste Generation

Determination of the per capita generation rate is conducted in the same way as it is for large multi-unit apartment buildings. The total weight of waste generation for the week is determined by weighing all the waste set out for collection. This weighing procedure may often be facilitated by contracting the normal waste hauler to make a dedicated pick of the waste (picking up no other waste in an empty truck), and returning the weigh scale information from the landfill or transfer station.

The total number of school students or residents in the institution is determined by contacting the institution. The "per capita" generation rate is then calculated based on the total weight of refuse and the total number of persons. In the case of schools, care should be made to determine the number of days people are at the institution, such as only 5 days per week for public and secondary schools.

9.2 Percent Waste Composition

Waste composition from schools and institutions can be determined by taking 100 kg samples and sorting the waste according to the composition categories used for residential waste. As with residential waste, ten samples (nine as a minimum) are required to obtain statistically valid results.

SECTION 10

RECOMMENDATIONS FOR FURTHER REFINEMENT

10.0 RECOMMENDATIONS FOR FURTHER REFINEMENT

Municipalities conducting a waste composition study might consider the following recommendations when designing the sampling protocol and implementing the study methodology.

1) For sampling and sorting convenience, municipalities may choose to conduct the waste composition studies in late spring or mid-fall when refuse odours are less intense and maggots are less frequently encountered. According to Vesling & Rimer (ref. 47), the average residential waste composition does not vary by more than +/- 10% over three quarters of the year. Therefore, aesthetics of the working conditions can be taken into account without risk to obtaining skewed data. The inclusion of yard waste in overall residential waste composition percent profiles should be avoided so that baseline composition percentages are not misrepresented.

2) Municipalities may choose to set up independent collection systems to study the seasonal generation of yard waste and leaves. This would require a coordinated effort between garbage collection personnel, private horticultural firms and other agencies generating and collecting these waste streams.

3) In order to avoid the sampling problems that we encountered with the large apartment buildings in East York, where apparent sampling biases were difficult to avoid, arrangements could be made, for example, with 30 units within the building to participate in a refuse study. This would give a more accurate appraisal of the waste composition in these large apartment buildings. As a check, the method described herein for obtaining the per capita generation rate for the entire building could then be compared with the per capita generation rate for the 30 units.

4) Municipalities in Ontario should follow the waste composition procedure in conducting their own waste composition analysis, for reasons of consistent data generation using a cost effective approach. Periodically, municipalities should conduct additional waste composition studies to monitor trends in residential waste management and the effectiveness of waste management programs.

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ACKNOWLEDGEMENTS

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Mr. Robert Ferguson, Commissioner of Works, Metro Toronto, gave permission to use the laboratory in the former Ontario Centre for Resource Recovery (OCRR) for the moisture analyses. Mr. Brad Guglietti, Waste Management Branch, MOE, arranged for the loan of a Sartorious balance for this work.

Borough of East York:

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They were steadfast and dedicated to fine tuning the procedures that were initiated by the Fergus crew.

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Mr. Robert Ferguson, Commissioner of Works, Metro Toronto, gave us permission to sort the East York refuse on the tipping floor of the Commissioners Street incinerator and to continue using the OCRR for the moisture analyses.

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City of North Bay:

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GLOSSARY

GLOSSARY OF TERMS

ABS	acryl butyl styrene; a dense plastic found in computer housings, telephone casings, pipe.
accuracy	in a statistical sense, the term gives an indication of the closeness of the results, estimates, etc. to the "true" value.
BTU	British Thermal Unit; the amount of heat required to raise the temperature of 1 pound of water 1 Fahrenheit degree
capture rate	The percentage of blue material diverted from landfill compared to the total quantity available for recycling;
commercial wastes	discarded materials generated by commercial businesses as a result of normal activities in the workplace;
ferrous	a metal object containing elemental iron, giving a `positive' or attractive response to a magnet;
mean	the mean or arithmetic mean of a set of values is the sum of the values divided by their number; average;
MSW	municipal solid waste, usually defined as the sum of residential and commercial solid wastes, and excluding industrial wastes;
non-ferrous	a metal object which does not give a `positive' or attractive response to a magnet, e.g., brass, lead, aluminum, etc.
OCC	old corrugated containers; variously called, old corrugated cardboard;

PET	polyethylene terephthalate; the plastic used to manufacture the common 2 litre pop bottles;
polyolefin	in the sense used here, a grouping of chemically related plastics whose chemical building blocks are either ethylene or propylene;
precision	in a statistical sense, the term gives an indication of the repeatability of a series of observations, estimates, etc. The Standard Error is one kind of estimate of the precision or repeatability or "tightness" of the grouping of the observations (=data);
putrescible	a material which is biodegradable; usually a term reserved for animal or vegetable matter;
PVC	polyvinyl chloride; a plastic containing chlorine; well known as siding, plastic window sashes and frames, pipe and a few rigid containers;
Random Number Table	These tables (which are found in many statistical textbooks) consist of blocks of numbers that meet certain properties of "randomness", including that numbers in the range 0 to 9 are equally likely to occur; and that the numbers are not serially ordered in any way. Starting at any point on the Table, the user moves systematically through the Table taking the required number of digits;
residential waste	discarded materials generated by individuals in the course of their daily activities at their place of residence; in this case, exclusive of yard wastes and leaves;
Standard Deviation	a measure of the variation or difference of sample measurements from the mean of all measurements taken;

Standard Error	a measure of how much sample means can be expected to fluctuate (±) from the true mean due to chance;
tare weight	the weight of an empty container;